UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and
Information Administration
Washington, D.C. 20230

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

RE: *Carrier Current Systems, including Broadband over Power Line Systems,* ET Docket No. 03-104, *Amendment of Part 15 regarding new requirements and measurement guidelines for Access Broadband over Power Line Systems*, ET Docket No. 04-37

Dear Ms. Dortch:

Enclosed please find an original and six (6) copies of late-filed comments of the National Telecommunications and Information Administration in the above-referenced proceedings. Please direct any questions you may have to the undersigned at (202) 482-1816.

Respectfully submitted,

Kathy D. Smith

Kathy D. Smith
Chief Counsel

Enclosures

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Before the
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In the Matter of	)	
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	)	
Amendment of Part 15 regarding new requirements and measurement guidelines for Access Broadband over Power Line Systems	)))	ET Docket No. 04-37

COMMENTS OF THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

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June 4, 2004

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SUMMARY

On March 26th, President Bush established a national objective to make broadband access available and affordable to every American by 2007 and called for "...technical standards to make possible new broadband technologies, such as the use of high-speed communications directly over powerlines."[1] To this end, NTIA has completed additional BPL studies that, with the NTIA Phase 1 study, provide the basis for NTIA's recommended framework of technical rules for Broadband over Power Line ("BPL") systems that will responsibly address interference concerns and BPL operational requirements. NTIA urges the Commission to promptly adopt effective technical rules to enable BPL proponents to develop and implement the necessary new design features and operating practices and obtain requisite new authorizations in time to contribute significantly toward fulfillment of the President's vision for universal affordable broadband Internet access.

NTIA recommends adoption of several new BPL rule elements that couple with the Commission's proposed rules to reduce risks of interference from BPL systems to authorized radiocommunications. These rules also help ensure that interference from BPL systems would be eliminated expeditiously with little effort needed on the part of any radio operator. Relative to existing BPL rules, these recommended new rules will shift the emphasis away from elimination of interference from BPL systems toward prevention of interference through adaptation of well-proven spectrum management practices.

The potential benefits of BPL identified in the Notice of Inquiry ("NOI") phase of this proceeding warrant acceptance of a small and manageable degree of interference risk. The risks

[1] President George W. Bush, Remarks at the American Association of Community Colleges Annual Convention, Minneapolis Convention Center, Minneapolis, Minnesota (April 26, 2004) (available at http://www.whitehouse.gov/news/releases/2004/20040426-6.html).

likely will be moderated by a concurrent reduction in existing interference risks from power line noise throughout the spectrum up to 600 MHz. Strong existing radio noise emissions from power lines often span frequencies well beyond those used for BPL - this noise must be reduced to enable acceptable Access BPL performance while complying with the proposed field strength limits. Moreover, in the long-term, BPL deployment should yield additional motivation and resources for maintaining the electric power distribution system, predicting and preventing faults, and achieving more rapid repairs in an affordable manner. Thus, although limited reliability of electrical power systems was cast by some parties as a BPL drawback in the NOI phase, widespread deployment of BPL may actually induce substantial reliability improvements.

Reduction of Interference Risks

To reduce risks of interference from BPL systems, NTIA endorses the Commission's proposed field strength limits and its thrust to refine BPL measurement provisions that ensure compliance with these limits. In addition, to ensure that the Commission's proposed BPL notification database is useful for interference prevention, NTIA recommends specification of voluntary *a priori* frequency coordination procedures in connection with a requirement for BPL operators to notify planned BPL deployments at least thirty days in advance of activation. Concerned shortwave broadcast listeners and other radio operators could inform BPL operators of their local radio reception parameters to enable the BPL operator to avoid co-frequency BPL operations that may pose high risks of interference. BPL operators also could identify local radio communications operations by consulting the Commission's database of licensed radio stations. In response to advance notifications, NTIA would provide information on local Federal Government radio receiver operations that will enable reduction of interference risks. Many Federal Government receivers are positioned at known, fixed locations. The custodian of the notification database could provide, on a web site, a standard form and e-mail address for alerting the BPL operator of potentially vulnerable radio operations.

NTIA also recommends mandatory power control and adoption of limited coordination areas, excluded frequency bands, and exclusion zones to protect the most sensitive and vulnerable Federal Government radio receivers. Because radio noise on power lines can vary by upwards of 20 dB throughout a day, a rule should require adjustment of BPL signal power to preclude unnecessarily high levels of radiated emissions. NTIA is evaluating the potential interference risk reductions accrued from power control, but it is obvious that reducing Access BPL emissions by about 20 dB (a factor of 100) when noise is at relatively low levels will substantially reduce interference risks. Prior to implementation of Access BPL in a coordination area, such as the National Radio Quiet Zone from which extraordinarily sensitive radio astronomy observations are made, the BPL operator should be required to contact the specified authority for the coordination area in order to mutually determine whether BPL constraints are needed to prevent interference. BPL operations should be prohibited nationally within certain excluded frequency bands, such as the band 74.8-75.2 MHz used for aircraft reception of marker beacons. BPL use of certain frequencies should also be prohibited in specified exclusion areas, for example, in small areas around United States Coast Guard ("Coast Guard") coast stations in the band 2173.5 – 2190.5 kHz used for Global Maritime Distress and Safety System communications.

Perhaps the most broadly effective reductions in BPL interference risks will be achieved through provisions for BPL compliance measurements. Existing Access BPL measurement provisions can mistakenly indicate compliance with field strength limits when the limits actually are substantially exceeded. NTIA agrees with the BPL Notice of Proposed Rulemaking (NPRM) proposals to measure at a one-meter height at a uniform distance of ten-meters to simplify measurement logistics. However, measurement at the distances along the power lines (fractions of a wavelength) proposed in the BPL NPRM will fail to reveal the peak field strength in many cases. To prevent underestimation of peak field strength during compliance measurements, NTIA recommends a comprehensive search for the peak field strength along the power lines at a height of one-meter. To avoid the need to search for the peak field in the height dimension as well, NTIA recommends use of a 5 dB height correction factor. NTIA's analysis shows that use of a 5 dB height correction factor with the peak field strength measured at a one-meter height is a good estimate of the electric field strength not exceeded at 80% of the heights above one-meter. Because power lines have frequency selective radiation properties and BPL device frequencies are, or should be, tunable in frequency, a rule should require measurement of Access BPL radiated emissions with the BPL system bandwidth successively tuned to cover every frequency at which the BPL system can operate. NTIA concurs with the BPL NPRM proposal to use a loop antenna at frequencies below 30 MHz and an electric field antenna at higher frequencies. However, because a loop antenna measures magnetic field strength and the measurements are performed in the near-field, NTIA recommends that an appropriate magnetic-to-electric field strength conversion factor be applied to enable correct comparisons of measurements with the electric field strength limit. In order to ensure that the highest representative field strength levels are measured and the limits are not exceeded, NTIA further recommends adoption of guidelines for judicious selection of the three Access BPL deployments for *in situ* measurements and a rule specifying how those measurements are to be applied. Representative spectral power distributions of Access BPL signals should also be measured and included in the measurement report to facilitate identification of the BPL signals in the event they cause interference.

Interference Mitigation

NTIA agrees with the BPL NPRM proposals to require that Access BPL systems be capable of shut-down and adjustment of frequency usage to eliminate interference. However, the rendition of shut-down requirements in 47 CFR 15.5(c) is inadequate and misleading in the unique case of Access BPL. Shut-down is a last resort after first attempting the many other interference mitigation techniques available to Access BPL systems. For example, to ensure that suspected interference from BPL systems is quickly diagnosed and eliminated if confirmed, NTIA recommends that each notification of BPL deployment include a telephone point-of-contact for receiving interference complaints. This point of contact should be required to immediately determine and report to the complainant whether the BPL system is locally using the frequencies at which interference is suspected. If this does not dismiss BPL as the possible cause of interference, the point-of-contact should be required to perform or schedule a simple test in cooperation with the complainant that will determine whether the Access BPL network element(s) are the likely cause of interference. Specifically, the suspected BPL network element(s) could be briefly shut off or BPL device frequencies could be changed to eliminate co-frequency operation while the complainant is operating the receiver and reporting its performance. To ensure that diagnosis of suspected interference can be conducted independently of the BPL operator if so desired, for each type of device to be deployed, Access BPL system notifications should include the modulation type(s), number(s) of carriers, minimum and maximum carrier spacing, symbol rate(s) per carrier, range of transmission duty cycle, and the multiple access technique. Insofar as BPL signal identification using these parameters requires a spectrum analyzer, NTIA is further considering whether a code signal should be transmitted to enable identification using a standard communications receiver - modulation of any such a code must not increase interference risks.

On the basis of worst-case oriented analyses of ionospheric propagation and aggregation of radiated emissions from Access BPL systems, NTIA concludes that hundreds of thousands of Access BPL devices conforming to current BPL rules (limits and measurement procedures) would have to be deployed nationally to cause a 1 dB increase in median radio noise power at any location, globally. Using NTIA's recommended rules, chiefly the mandatory power control and use of a 5 dB height correction factor, it would take millions of BPL devices to cause a 1 dB increase in median radio noise. NTIA is further studying this phenomenon and recommends that BPL advance notifications include the maximum number of Access BPL devices that will be deployed. These entries should be updated quarterly to reflect actual deployment in order to enable on-going predictions of ionospheric propagation and aggregation of BPL emissions to forecast the onset of any significant increase in radio noise levels. Thus, this is not a potential near-term issue that should delay adoption of BPL rules.

Other Authorization Provisions

Other Access BPL authorization provisions should require certification by the operator rather than verification by the manufacturer. This will align benefits and obligations with the responsible party, who will have strong incentives to minimize interference risks. Certification is appropriate because interference risks posed by Access BPL systems are high relative to other unintentional emitters and the newness of the Access BPL measurement procedures warrants review of measurement reports. NTIA agrees with the definition of Access BPL proposed in the BPL NPRM and recommends adoption of a complementary definition for In-House BPL. This would properly frame the respective rules and measurement guidelines to avoid misinterpretation or overlooking of applicable rules. The measurement provisions most important to prevention of interference should be codified as rules rather than guidelines. For example, compliance measurement bandwidth should be a rule rather than a provision incorporated by reference in guidelines, because use of measurement bandwidths other than the intended 9 kHz and 120 kHz values could yield significant error and elevated risk of interference.

Recommended Near-Term Rulemaking Actions

Thus, in light of the scope of available studies and other evidence, NTIA further recommends that the Commission proceed expeditiously to rulemaking for In-House BPL and Access BPL using low- and medium-voltage ("LV" and "MV") power lines. NTIA concurs with the BPL NPRM proposal to review measurement guidelines for In-House BPL later, after international studies are completed. NTIA believes that expressed interest as well as available technical descriptions, operating experience and studies of potential interference are inadequate at this time to support establishment of rules for Access BPL using high voltage ("HV") transmission lines or any BPL use of frequencies outside the 1705 kHz to 80 MHz frequency range. This, too, could be revisited later. Finally, NTIA recommends establishing a new, dedicated rule part or sub-part of Part 15 for Access BPL. This recommendation is made because the Access BPL rules proposed in this NPRM are substantial, unique to Access BPL, and would be difficult to understand if incorporated into Part 15 of the Commission's Rules. Moreover, certain existing Part 15 rules for unintentional emitters should not be applied to Access BPL.

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COMMENTS OF THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

The National Telecommunications and Information Administration (NTIA), an Executive Branch agency within the Department of Commerce, is the President's principal adviser on domestic and international telecommunications policy, including policies relating to the nation's economic and technological advancement in telecommunications. Accordingly, NTIA makes recommendations regarding telecommunications policies and presents Executive Branch views on telecommunications matters to the Congress, the Federal Communications Commission (Commission), and the public. NTIA is also responsible for managing the Federal Government's use of the radio frequency spectrum. NTIA submits these comments in response to the Commission's Notice of Proposed Rulemaking in the above-captioned proceeding.[2] These comments make frequent reference to NTIA's recently released Phase 1 report addressing potential interference from Broadband over Power Line ("BPL") systems, as supplemented by the preliminary elements of NTIA's Phase 2 report that are presented in the Technical

[2] Amendment of Part 15 regarding new requirements and measurement guidelines for Access Broadband over Power Line Systems, ET Docket 04-37, Notice of Proposed Rulemaking, FCC 04-29, released February 23, 2004, ("BPL NPRM").

Appendix, herewith.[3] NTIA has coordinated these comments with the Interdepartment Radio Advisory Committee ("IRAC").

DISCUSSION

In the Notice of Inquiry ("NOI") phase of this BPL proceeding, thousands of commenters expressed various degrees of support and opposition for BPL.[4] Proponents concluded that harmful interference is not expected but can be eliminated through various means if it occurs. Numerous other parties envisaged scenarios under which BPL systems could cause harmful interference to radio communications. NTIA believes that all of these views are reasonable because both interference-free and harmful interference scenarios could occur.[5] Thus, NTIA has focused on the following technical questions:

- What interference risks are posed by BPL, and if they are too high, how can the risks be suitably reduced while fulfilling at least the minimum BPL requirements?
- If interference from a BPL system is suspected, what are the difficulties in diagnosing the suspected interference and eliminating harmful interference?[6]

As set forth herein and in the BPL NPRM, satisfactory answers to those technical questions are available for In-House and Access BPL systems using low- and medium-voltage

[3] "Potential Interference From Broadband Over Power Line (BPL) Systems To Federal Government Radiocommunications at 1.7 – 80 MHz," NTIA Report 04-413, April 2004 ("NTIA Phase 1 study"). Available for download at NTIA's web site, URL: www.ntia.doc.gov.

[4] *Inquiry Regarding Carrier Current Systems, including Broadband over Power Line Systems*, ET Docket 03-104, released April 28, 2003 ("BPL Inquiry").

[5] Devices authorized under Part 15 of the Commission's Rules generally are capable of causing harmful interference when concurrently operating with a co-located, co-frequency radio receiver. The rule provides that "[p]arties responsible for equipment compliance should note that the limits specified in this part will not prevent harmful interference under all circumstances." 47 CFR 15.15(c).

[6] NTIA refers to suspected interference because in many cases, degradation of reception is the result of problems in the receiver, its antenna, or the interconnecting transmission line. For example, rodents sometimes chew coaxial cables or twin-lead transmission lines and cause significant reductions or complete loss of the desired signal power that should reach the receiver. In many other cases, interference is realized but not caused by the suspected device.

("LV" and "MV") power lines. NTIA believes that this rulemaking is timely for application of those technical answers in appropriate regulatory solutions that reflect careful limitation and management of interference risks. NTIA's vantage point includes many years of experience in successful management of interference risks. The rules must ensure that BPL systems will consume only a small amount of spectrum resources, not otherwise utilized by radio systems.

The technical answers at hand for In-House and LV/MV Access BPL are reliable and should be applied as soon as possible. NTIA has not studied Access BPL systems that use high-voltage ("HV") transmission lines and suggests that this highly-specialized form of BPL be considered later. Moreover, compliance measurement procedures for In-House BPL systems procedures should also be revisited later as suggested by the Commission.[7] Rather than delay this rulemaking until these and perhaps other issues are further addressed, NTIA prefers to proceed expeditiously with this rulemaking in order to establish modified rules that yield reduced interference risks and greater regulatory certainty for BPL proponents and radio interests alike. BPL using HV transmission lines and measurement guidelines for In-House BPL can be revisited later.

I. NTIA CONCURS WITH THE COMMISSION'S DEFINITION OF ACCESS BPL AND SUGGESTS ADOPTION OF A DEFINITION FOR IN-HOUSE BPL

The Commission proposes a definition for "Access BPL" that includes in its scope all "...electric power lines owned, operated or controlled by an electric service provider."[8] NTIA agrees with this definition and that it is needed in order to properly specify the rules and measurement guidelines applicable to Access BPL. Likewise, the Commission should consider a definition of "In-House BPL" to properly frame the applicable rules and measurement guidelines.

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[7] BPL NPRM, at ¶47.

[8] BPL NPRM, at ¶32 and Appendix B, ¶2.

Adoption of a definition for In-House BPL together with the Access BPL definition would fully define all forms of BPL. To this end, NTIA suggests the following draft definition:

> In-House Broadband over Power Line (In-House BPL): A carrier current system that transmits radio frequency energy by conduction over electrical power lines that are not owned, operated or controlled by an electric service provider. The electric power lines may be aerial (overhead), underground, or inside walls, floors or ceilings of user premises. In-House BPL devices may establish closed networks within the user premises or provide connections to Access BPL networks, or both.

II. BPL IS A WIN-WIN PROPOSITION TO THE EXTENT THAT EXISTING AND FUTURE POWER LINE NOISE PROBLEMS ARE REDUCED

The many potential public benefits of BPL technology and BPL capabilities for eliminating interference argue strongly for accepting a degree of interference risk.[9] In fact, existing power line noise and reliability problems that were cast as BPL detriments in the NOI phase of this proceeding likely will be remedied as a result of widespread Access BPL deployment. NTIA does not expect Access BPL systems to compound existing risks of interference from radio frequency noise generated by electrical power distribution systems – a problem that has been explained in numerous comments.[10] Instead, to the benefit of radio proponents, strong power line noise emissions likely will be reduced in the process of deploying BPL systems. Many commenters noted that electrical power distribution systems occasionally fail (*e.g.*, during adverse weather) and concluded that BPL will not be reliable.[11] NTIA disagrees and believes that in the long-term, Access BPL likely will induce improved reliability of the electrical power distribution system and enable more expeditious restoration of electrical service

[9] BPL NPRM, at ¶¶1, 3, and 10-13.

[10] In Comments in response to the BPL Inquiry (July 7, 2003), ARRL argues that "[p]ower line noise is the single most frequently identified source of HF interference to licensed Amateur Radio operators." ARRL Comments at ¶3. In Comments in response to the BPL Inquiry (July 7, 2003), Ambient Corporation states "[i]n the absence of BPL, noisy power lines may create interference with existing spectrum uses." Ambient Corporation Comments at 9.

[11] *See, e.g.*, Comments in response to the BPL Inquiry of: Joseph Hance, February 28, 2004, at ¶1; Donald T. Lane, February 20, 2004, at ¶1; Richard Casey, February 27, 2004, at ¶2; David Norris, March 1, 2004, at ¶3.

when failures occur. NTIA believes that such a reliability enhancement to critical infrastructure would greatly benefit individuals, businesses and the government – everyone - regardless of whether they subscribe to Access BPL.

Reduction of strong power line noise is a basic technical requirement necessary for acceptable performance of BPL systems under the field strength limits proposed by the Commission and endorsed by NTIA. As in radio systems, the signal-to-noise power ratio ("S/N") at BPL receivers must exceed certain thresholds in order to achieve reliable transmission with the requisite throughput. If the noise power at the BPL receiver is unnecessarily high, the BPL signal levels also will have to be unnecessarily high. Reducing power line noise can enable reductions in BPL signal power such that operation near the field strength limit may not be needed. Most strong power line noise emissions span not only the frequencies of prime interest for BPL operations, but also many other radio frequencies at Medium Frequency (MF), High Frequency (HF), Very High Frequency (VHF) and lower Ultra High Frequency (UHF) bands not used by BPL (generally spectrum below 600 MHz). Thus, reducing power line noise should reduce certain interference risks, perhaps including risks at frequencies used by the BPL system. Moreover, deployment of BPL could increase the likelihood that problematic power line noise will be diagnosed and repaired.

Apart from the BPL measurement campaigns, NTIA has measured field strength levels from power line noise that are higher than the limits proposed for BPL radiated emissions and these existing anomalies pose greater local interference risks than Access BPL. In contrast, during its BPL measurements, NTIA observed that power line noise levels in the vicinity of BPL systems were substantially lower than predicted typical levels that include as a component the typical levels of power line noise. Substitution of BPL emissions for the strong, much widerbandwidth power line noise emissions will broadly reduce risks of interference to radiocommunications. This is not to say that NTIA expects there will be a net, nationwide reduction of interference risks; instead, NTIA believes there will be at least partial offsetting of the interference risks posed by BPL.

When considering the reliability aspects of electrical service and Access BPL, it is instructive to consider electrical service failures and restoration under scenarios that include and exclude widespread BPL deployment. Presently, without Access BPL, electrical utility companies: maintain substantial crews and equipment sufficient to rapidly repair certain numbers and geographic distributions of failures; monitor and forecast adverse weather and other leading indicators of potential failures in order to marshal resources in advance of potential failures; and pool service restoration resources among companies in preparation for numerous, potentially widespread failures. Detection and diagnosis of many types of failures rely on "complaints" from electricity consumers. These operations balance the costs of electrical service with the amount of resources available for diagnosis and repair of failures. With widespread deployment of Access BPL, however, it will be possible to speed detection and diagnosis of electrical system failures and there likely will be increased demand and revenue subsidies for qualified electric system repair and maintenance personnel and equipment.[12] In today's high-productivity environment, by adding Access BPL to the equation, the new manpower and equipment needed to install and maintain BPL systems likely will create economies of scale that benefit the reliability of both electrical power distribution and BPL.

[12] David Tobenkin, Comments at 9 (December 24, 2003).

III. NTIA AGREES WITH THE COMMISSION'S TREATMENT OF EMISSION LIMITS AND RECOMMENDS THAT SUPPLEMENTAL EMISSION RESTRICTIONS BE EMPLOYED IN LIMITED FREQUENCY BANDS AND GEOGRAPHIC AREAS

NTIA concurs with the Commission's proposal to continue to make Access BPL systems subject to existing radiated emissions limits for carrier current systems.[13] Perceived BPL interference risks preclude relaxation of radiated emission limits for BPL systems, and interference risks can and should be suitably reduced through refinement of the compliance measurement provisions.[14] However, additional emission restrictions are needed in certain frequency bands and geographic areas in order to protect radiocommunications consistent with current rules and practices. These restrictions would have the following forms: geographic "coordination areas," wherein BPL deployments at any frequency in those areas must be pre-coordinated by BPL operators; excluded bands, in which certain frequencies are not to be used by BPL in any geographic area; and small geographic "exclusion zones," wherein BPL emissions are forbidden at specified frequencies in accordance with protection requirements and electromagnetic compatibility studies. These coordination areas, excluded bands and exclusion zones would be defined in the rules for Access BPL systems and would virtually eliminate certain interference risks. For example, the National Radio Quiet Zone ("NRQZ") would be a BPL coordination area; the band 74.8-75.2 MHz used for aircraft reception of marker beacons used in conjunction with the Instrument Landing System ("ILS") would be an excluded band; and there would be exclusion zones around Coast Guard coast stations in the 2173.5 - 2190.5 kHz band used for distress alerting.[15] BPL proponents have already demonstrated capabilities

[13] BPL NPRM, at ¶33 and Appendix B, ¶4.

[14] NTIA BPL Phase 1 study, §7.12, and Technical Appendix, at §§2, 3 and 5.

[15] *See* Phase 1 study, §4.6. The NRQZ exists to protect radioastronomy operations at Green Bank, West Virginia. *See* 47 CFR 21.113. Spectrum management authorities of the NRQZ already enjoy excellent rapport with the local electric utility operator for the cooperative elimination of power line noise. Intentional emissions by Part 15 devices

for implementing these restrictions, *e.g.*, by notching out frequencies allocated to the amateur radio service. NTIA believes that only a minimal number of such restrictions should be codified in the rules in light of the *a priori* frequency coordination procedures NTIA recommends. NTIA is continuing to study potential coordination areas, excluded bands and exclusion zones to identify the minimum requisite set of such restrictions.

IV. THE COMMISSION'S ACCESS BPL OPERATIONAL REQUIREMENTS WILL BE EFFECTIVE AND NTIA SUGGESTS IMPLEMENTATION OF COORDINATION PROCEDURES TO FURTHER REDUCE INTERFERENCE RISKS

NTIA believes that BPL operators, as the parties responsible for eliminating harmful interference, will voluntarily implement equipment, organizational elements, and installation and operating practices that prevent interference and facilitate interference mitigation. Market appeal of BPL could quickly evaporate if BPL systems were to endemically cause interference and have to be shut down with operating authorizations swiftly revoked if necessary.[16] Thus, BPL operators have strong incentives to prevent and eliminate interference. However, to preserve the high degree of regulatory certainty enjoyed by licensed radio operators, the rules for Access BPL should require implementation of the most widely effective operational features for preventing and eliminating interference. The Commission proposes to require BPL systems to have operational capabilities such as dynamic or commanded power reduction, commanded shut-down, and local exclusion of BPL use of specific frequencies or bands.[17] The Commission also

are forbidden at 2173.5 - 2190.5 kHz in order to protect maritime and aeronautical distress alerting and other safety communications. *See* 47 CFR 15.205. Although BPL radiated emissions are unintentional, distress and safety communications in the 2173.5-2190.5 kHz band must be possible using the weakest, barely intelligible signals that are highly vulnerable to interference. The ILS system is an aeronautical radionavigation system. By definition, "harmful interference" is "[i]nterference which endangers the functioning of a radionavigation service or of other safety services..." and the interference risks posed by BPL systems constitute such endangerment. 47 CFR 2.1.

[16] Conditions for revocation of equipment authorizations are specified in 47 CFR 2.939.

[17] BPL NPRM at ¶¶40 - 42 and Appendix B, ¶4.

proposes a requirement that BPL operators notify key BPL system parameters to an industry-operated entity that will enter and maintain these parameters in a publicly accessible database.[18] NTIA fully supports those proposals as discussed below and proposes to require *a priori* coordination of potentially affected receiving stations at known locations or service areas. NTIA believes that imposition of coordination requirements on BPL operators to receive and consider coordination data will not result in significant costs while providing the substantial benefit of preventing interference to radio receivers at known locations. Further, to speed resolution of cases of suspected interference, NTIA recommends that BPL operators be required to promptly diagnose suspected interference and eliminate actual interference from BPL systems.

Adaptive or commanded power control reduces interference risks by maintaining the desired signal near the requisite, minimum power level, in response to measured or predicted transmission channel conditions. Power line noise resulting from ingress of ambient radio noise can vary by upwards of 20 dB throughout the day and seasonally, especially at frequencies below 12 MHz. Additional variations in power line noise power can arise at frequencies generally below 600 MHz from faults in power distribution components and operation of certain customer premises equipment. Rather than setting BPL device output power at a constant level that is high enough to yield the requisite BPL S/N during peak noise levels, interference risks can be significantly reduced by adjusting power consistent with variations in noise power that cannot reasonably be eliminated prior to BPL deployment. Assuming that protection of local receivers at locations is pre-coordinated, as discussed below, BPL power increases can be suitably limited or locked-out at the locally used radio frequencies as needed.

BPL frequency tuning capabilities can be used to prevent or rapidly diagnose and

[18] BPL NPRM at ¶43 and Appendix B, ¶4.

eliminate interference. Interference would be prevented by precluding BPL operation on locally used frequencies when there is insufficient distance separation for interference-free, co-frequency operation with respect to radio receivers at known nearby locations. This includes mobile receivers at frequencies above 30 MHz that routinely operate within a known base station coverage area.[19] The distance separation criteria for virtually risk-free, co-frequency operation would be applied by the BPL operator when selecting BPL frequencies within pre-established coordination zones or in the course of the frequency coordination in response to BPL deployment notifications. To quickly diagnose claims of interference while sustaining BPL service, the BPL operator could determine whether a BPL system is the cause of suspected interference by shifting its operating frequency. If it is determined that the BPL system is causing interference, the interfering BPL system could be commanded to use only non-interfering frequencies. To achieve these benefits, NTIA believes that BPL systems should be required to have frequency agility that is capable of precluding BPL transmissions in bands of at least 3 kHz at frequencies below 30 MHz and 30 kHz at frequencies above 30 MHz. In addition, insofar as many BPL frequency constraints may be needed at some locations, it would be beneficial if BPL devices were capable of using frequencies anywhere throughout the frequency range authorized for BPL operations. Furthermore, to avoid potentially impairing mobile radiocommunications over sizable contiguous areas, geographically adjacent Access BPL network elements should not use the same frequency bands if the bands are used by mobile radio receivers.

The Access BPL deployment notification requirements proposed by the Commission should be made retroactive and BPL operators should be required to notify planned deployments at least 30 days in advance of implementation and to consider the coordination data they receive

[19] A mobile receiver operating via ionospheric signal propagation can be located virtually anywhere relative to a base station or other mobile stations with which it is communicating.

regarding local radio receiver operations in order to prevent interference. Spectrum management science and engineering have yielded various applicable algorithms for optimally planning frequency usage that avoids risking interference. Advance notification would, via e-mails, allow local radio receiver operators to inform the BPL operator of potential interference situations involving radio receivers at known locations or mobile receivers that are routinely operated in the planned deployment area. This action would be voluntary on the part of any radio operator. BPL operators should extract local frequency assignment data from the pertinent Commission databases, identify the locations and frequencies used by local radio receivers, and plan BPL operating frequencies in a manner that avoids BPL interference to local co-frequency radio receivers.[20] To protect federal government radio communications, in response to each advance notification, NTIA plans to provide the BPL operator with information that will enable prevention of interference to local federal radio operations. To effect this frequency coordination, a single, centralized, web-based database should provide details of planned BPL system deployments sufficient to enable identification of local radio operations that may be affected. NTIA recommends that planned BPL system locations be notified in the form of one or more geographic coordinates (in decimal degrees) and associated radii (in kilometers). One or more such coordinate-radii pairs should be notified to describe a planned, near-term deployment area without including an excessive amount of area outside the area where deployment is planned. NTIA further recommends notification of the earliest anticipated date of actual operation within each deployment area so that NTIA can properly prioritize its responses to notifications.

[20] When applied with appropriate distance separation guidelines for co-frequency BPL and radio operations, the BPL operator can determine frequency plans for Access BPL network elements that avoid certain locally used radio frequencies where necessary to prevent interference.

To facilitate radio operator diagnosis of suspected interference from BPL systems, notifications of Access BPL deployments should include the BPL device multiple access technique, modulation details (modulation type, carrier spacing parameters and data rate on each carrier), and the method of power control. The multiple access technique and modulation details would sufficiently describe the BPL emission waveforms to enable identification of BPL emissions using a spectrum analyzer. BPL transmission of identifying codes could facilitate identification of BPL emissions using a conventional radio receiver; however, NTIA is further considering the potential need and whether transmission of such codes would increase interference risks. Using these notified parameters, diagnosis and confirmation of suspected BPL interference could be made independently of the BPL operator, if so desired. However, there should be no fundamental need for such actions if, as NTIA recommends, the BPL operator is required to quickly diagnose suspected interference and eliminate harmful interference upon complaint.

Advance notifications for each deployment area should also specify the maximum number of each type of Access BPL device to be deployed in the specified area. Subsequent notifications should be submitted at least quarterly for each deployment area, as needed, to report the total numbers of each type of device that have been deployed and to update other advance notification parameters. The identity of the device manufacturer(s) should not be included in these notifications without their explicit approval. Among other things, over time this data will assist NTIA in updating its predictions of increases in ambient radio noise due to ionospheric propagation and aggregation of emissions from BPL devices. NTIA's studies to date indicate that such a problem could occur only well in the future after hundreds of thousands or perhaps millions of Access BPL devices are deployed. *See* Technical Appendix, §4.

To further facilitate diagnosis of suspected BPL interference and elimination of actual BPL interference, NTIA suggests that each BPL operator be required to provide a single, telephone point of contact for each deployment area in addition to the e-mail address NTIA suggests for purposes of frequency coordination. The telephone point of contact should be required to receive complaints of suspected interference and be capable of accomplishing rapid diagnosis during the same telephone session, or shortly thereafter, by a mutually agreed schedule. Specifically, upon receipt of such a telephone call, the BPL operator should perform or schedule a test in which the frequency(ies) of the suspected BPL interference source(s) is (are) changed to determine whether this test eliminates the interference. Alternatively, the BPL operator could perform this test by briefly deactivating the suspected BPL interference source(s) (*e.g.*, during a time of little or no traffic on the BPL network element(s) involved). These simple, rapid tests would determine whether the BPL operations are likely causing interference. This requirement would enhance the utility of the proposed shut-down and frequency agility capabilities and expedite resolution of cases of actual interference. NTIA has sufficient evidence that shows such a requirement is practicable and effective. In the course of conducting BPL measurements, NTIA personnel requested shut-downs and confirmations of BPL frequency usage via telephone and these requests were executed in a matter of seconds under pre-arranged conditions. Although such speedy responses may not be routinely practicable in response to complaints of suspected interference, a requirement to be capable of frequency shifts or shut-down of BPL network elements coupled with the BPL operators' incentives to preclude filings of interference complaints with the Commission should yield prompt resolution of cases of suspected BPL interference.

V. NTIA RECOMMENDS CERTIFICATION BY ACCESS BPL OPERATORS RATHER THAN VERIFICATION BY MANUFACTURERS TO ALIGN AUTHORIZATION OBLIGATIONS AND BENEFITS WITH THE RESPONSIBLE PARTY

NTIA recommends that Access BPL systems be authorized under the Commission's certification procedures rather than verification procedures as proposed in the BPL NPRM.[21] Although many unintentional emitters are subject to verification procedures, NTIA believes that Access BPL devices pose interference risks that are among the highest of the various kinds of authorized, unlicensed devices. Moreover, the requisite compliance measurement guidelines are new and untried. NTIA further recommends that authorizations for In-House BPL devices continue to be granted to BPL equipment manufacturers upon verification but that authorizations for Access BPL systems be granted to each qualified operator rather than the Access device manufacturers.

Under the Part 15 framework, the device manufacturer is responsible for compliance testing and the device operator is responsible for eliminating any harmful interference the device may cause. This divorcing of compliance testing and interference resolution responsibilities is reasonable for devices that are marketed to the general public and pose very low interference risk. However, all these responsibilities should be aligned and placed on Access BPL operators because they receive the BPL service revenue benefit and have strong incentives to ensure that interference risks are properly limited and technical standards are not violated. A somewhat analogous focus of responsibilities is made for cable television systems.[22] This assignment of responsibilities should obviate the need for any special labeling of Access BPL devices.

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[21] Certification procedures and requirements are specified in 47 CFR 2.1031-1057 and 15.101.

[22] Ideal coaxial cable TV distribution systems are not expected to radiate emissions; however, actual cable systems unintentionally radiate emissions from faulty connections, unauthorized cable set-top boxes, points where cable or amplifier shielding is poor, and improper cable terminations. Cable set top boxes are subject to manufacturer

Manufacturers of In-House BPL devices should continue to be subject to Part 15 compliance measurements and labeling requirements and receive the authorizations consistent with current provisions of rule Parts 2 and 15.

Because Access BPL systems pose relatively high interference risks, certification rather than verification should be required. Measurement procedures being considered for Access BPL systems are new and unique. Thus, the Commission should have the opportunity to review the measurement reports that must be submitted with applications for authorizations that are subject to certification. The Commission's repository of measurement reports may help diagnose any systematic interference that may arise from BPL systems, such as cases involving particular power line configurations or specific types of devices; however, NTIA's studies do not indicate that systematic interference problems should be expected.

VI. NTIA SUPPORTS THE COMMISSION'S PROPOSED MEASUREMENT GUIDELINES AND SUGGESTS ADDITIONAL STEPS TO FURTHER REDUCE INTERFERENCE RISKS

The BPL Inquiry stated that existing Part 15 rules "...do not specifically provide measurement procedures that apply to systems using the power line as a transmission medium."[23] NTIA's Phase 1 Study showed that refinements, clarifications and adaptations of Part 15 compliance measurement provisions are needed for Access BPL systems to reduce potential measurement inaccuracies and improve the validity of results for all deployed BPL systems. Otherwise, the existing field strength limits provide inadequate certainty that interference risks will be confined to the levels allowed by the field strength limits and other provisions. The Commission independently arrived at the same conclusion and proposed a number of BPL

Declaration of Conformity as specified in 47 CFR 15 and the balance of the cable distribution system is subject to operator measurement under Part 76.

[23] BPL Inquiry at ¶2.

compliance measurement provisions that account for unique characteristics of BPL systems.[24] NTIA's understanding of key proposed revisions to measurement guidelines and recommended refinements are presented below.

A. A MEASUREMENT DISTANCE OF TEN METERS SHOULD BE USED WITH RESPECT TO OVERHEAD POWER LINES AND BPL DEVICES WITH A MODIFIED DISTANCE EXTRAPOLATION FACTOR

Part 15 specifications of different measurement distances for frequencies below and above 30 MHz and, particularly, the thirty-meter measurement distance specified for frequencies below 30 MHz present logistical complications during *in situ* measurements. NTIA agrees and endorses the Commission's solution to require a uniform measurement distance of ten meters. However, NTIA's measurements and modeling indicate that the change in BPL field strength with increasing distance from the BPL device and power lines is not well approximated by the existing Part 15 distance extrapolation factor.[25] NTIA's recommended solution to this anomaly is to uniformly apply a ten-meter standard measurement distance, present explicit equivalent field strength limits for those distances, and provide the appropriate distance extrapolation. NTIA is further reviewing the Commission's proposal to utilize the slant-path distance to the power line as a basis for extrapolation.[26]

A ten-meter horizontal measurement distance already is specified for Class A radiated emission limits (*i.e.*, for frequencies above 30 MHz), and so, legacy measurements made at this distance will remain useful. Establishing this same measurement distance uniformly for other Access BPL limits will ease the measurement burden by eliminating two other measurement

[24] BPL NPRM at ¶¶ 45-47 and Appendix C.

[25] 47 CFR 15.31(f) applies 20 dB and 40 dB per decade distance extrapolation factors to adjust field strength measured at a distance other than the specified measurement distance.

[26] BPL NPRM at ¶46.

distances for BPL systems. This logistical easement will enable better focus on other, more complicated measurement provisions that may introduce new burdens. Moreover, a ten-meter measurement distance appears to satisfy important criteria of safety, measurement sensitivity, and avoidance of misinterpretation of local field strength peaks as being the overall peak emission level. While field strength can fall and increase with increasing distance well beyond the recommended ten-meter measurement distance, the overall peak level consistently occurs at one or more locations within ten meters of the power lines and BPL device. Secondary local field strength peaks further than ten meters from the power lines and Access BPL devices generally are substantially lower than the overall peak; hence, they will pose substantially less interference risk than arises at locations where field strengths are near the limiting value.

The BPL NPRM proposes to allow measurement at a horizontal distance of three meters in cases where a ten-meter measurement distance is not practicable. NTIA agrees that alternative measurement distances should be permitted and utilized when necessary. NTIA further recommends that specific field strength limits should be specified for the ten-meter measurement distance at all permissible BPL operating frequencies. In other words, the new BPL rules will have already applied appropriate distance extrapolations in the specification of equivalent field strength limits at the new ten-meter measurement distance. NTIA is developing equivalent field strength limits and distance extrapolation factors on the basis of the radiation and propagation properties of Access BPL emissions and will provide its findings as soon as possible.

B. MEASUREMENTS SHOULD FULLY ADDRESS RADIATION FROM BPL DEVICES AND POWER LINES TO WHICH THEY ARE CONNECTED

Certain Part 15 provisions require that measurements be made on radials emanating from the device under test, which assumes that the device under test is the radiating element generating peak levels of field strength.[27] However, NTIA measurements and analyses show that in most cases, peak field strength levels are not centered on the BPL device and multiple segments of the power lines and impedance discontinuities are the most significant BPL signal radiating elements.[28] Thus, BPL compliance measurements should address both the BPL device and the power lines to which it is connected.

NTIA's BPL measurements discovered that the peak BPL field strength is not necessarily located at the BPL device. This unusual phenomenon was confirmed and further investigated by evaluating numerous models of BPL devices and power lines using the Numerical Electromagnetic Code ("NEC") to predict radiated fields. For the case of a two-meter high, horizontally polarized measurement antenna that is oriented parallel to the power lines (*i.e.*, a typical height for land mobile receiver antennas), NEC analysis of simple power line models shows the peak electric field to be centered at or near the BPL power line coupler. However, when the same horizontally polarized measurement antenna is reoriented to be perpendicular to the power lines, NEC shows multiple peaks of BPL electric field strength occurring at locations tens of feet from the power lines and BPL devices. Peak vertically polarized electric fields at a height of two meters occur at several locations under power lines at various distances from the BPL device.

NTIA's further analysis of radiated emissions from overhead Access BPL systems shows that relatively high emissions can occur at various distances from the BPL device along the power line, in some cases at regular distance intervals. *See* Technical Appendix, §3. The peak field strength level can occur at any fraction or multiple of a wavelength from the BPL emitter.

[27] 47 CFR 15.31(f)(5)

[28] *See* NTIA Phase 1 study, §5 and Appendixes D and E.

Thus, the proposed Access BPL measurements at distances of 0, 1/4, 1/2, 3/4 and 1 wavelength along the power line from the BPL emitter may not consistently reveal the peak level of radiated emissions. NTIA recommends a comprehensive search for the overall peak field strength at the one-meter measurement height along key segments of the power lines at the specified horizontal measurement distance. This should not amount to an undue measurement burden insofar as local peaks of field strength often occur at regular distance intervals along the power line and measurement personnel will be able to fairly quickly identify the location of peak field strength. NTIA is further studying field strength trends along the power lines and intends to provide additional guidelines to facilitate identification of the peak field strength and its location (*i.e.*, the key power line segments where the peak is likely to be found). However, this proceeding should not await development of such guidelines because their purpose is to ease measurement burdens rather than establish fundamental requirements.

C. MEASUREMENT ANTENNA HEIGHT SHOULD BE ONE METER AND A 5 dB HEIGHT CORRECTION FACTOR SHOULD BE APPLIED

Measurements must ensure BPL compliance with field strength limits in all directions of radiation associated with the most likely cases of potential interference, including rooftop locations higher than power lines.[29] Conceptually, this can be accomplished either through direct measurement at various heights and directions or by application of a standard measurement antenna height with an adjustment factor that accounts for other heights. NTIA concurs with the Commission's proposed one-meter antenna measurement height even though the vast majority of radio receiver antennas used by the federal government are two meters or higher above the ground (*e.g.*, vehicles, building roofs, towers, and aircraft). The existing Part 15 and American

[29] Many radio receivers operating in the 1.7-80 MHz frequency range use antennas located at or above the heights of local power lines. Compliance with field strength limits at and above the power line height also controls the

National Standards Institute standard measurement antenna height of one meter is associated with compliance measurements at an open air test site ("OATS") at which associated ground reflection effects are controlled and have been factored in calibration of signal propagation and measurement antenna gain, but the one meter height can be reliably used with a height correction factor outside of the pristine OATS environment.

NTIA's assessment of the relationship between field strength from overhead Access BPL systems and measurement height above ground level has confirmed that peak field strength often occurs near the height of the power lines carrying BPL signals. *See* Technical Appendix, §2. However, the peak BPL field strength can occur at other heights well below and above the power line, and there is no clear, consistent trend with frequency or other parameters that may guide measurement personnel. In apparent recognition of this phenomenon, the Commission proposes to vary measurement antenna height between one and four meters at frequencies above 30 MHz as is the norm for compliance testing at an Open Air Test Site. Rather than require a measurement search for the peak BPL field strength in both height and distance along the power line, however, NTIA believes that measurement height should be addressed using a height correction factor. NTIA's analysis shows that a 5 dB height correction factor used in connection with measurements at a one-meter height would fulfill this goal.

Using NEC models, NTIA has evaluated the distributions of heights and magnitudes of peak field strength from over one-thousand combinations of nineteen power line configurations, polarization and location, at each of twenty-five BPL operating frequencies. This analysis reveals that 80 percent of the local field strength peaks at any height will be within 5 dB of the peak electric field strength measured along the power line at a height of one meter. In the large

composite interfering signal level generated at distant receivers by ionospheric propagation of unintentional emissions from widely deployed BPL devices. This mechanism is being investigated in phase 2 of NTIA's studies.

number of potential cases modeled by NTIA, the field strength at any polarization exceeds the peak value measured one-meter height by up to 20 dB in small spatial regions. Use of the 80 percentile value of 5 dB rather than the 100 percentile value of about 20 dB avoids undue constraint on BPL systems without significant impact on interference risks. Thus, NTIA recommends that at all frequencies, the peak field strength should be estimated to be 5 dB higher than the peak value measured along the power line at one-meter height. NTIA further recommends that for each representative BPL deployment, the locations and magnitudes of the six highest field strength levels measured at one meter height (plus 5 dB height correction factor) be recorded in the measurement report for overhead Access BPL systems.

D. ALL BPL OPERATING FREQUENCIES SHOULD BE CONSIDERED AND BPL EQUIPMENT SHOULD INCORPORATE THE NECESSARY OPERATIONAL POWER CONSTRAINTS

Existing Part 15 measurement guidelines generally are tailored for devices that operate at fixed frequencies or have uniform emission characteristics over the tuning range of the device. However, Access BPL systems have, or should have the frequency agility proposed in the NPRM. Access BPL radiation characteristics are not uniform across all possible operating frequencies. Thus, to properly address frequency-selective radiation characteristics, measurements should be made sequentially with the Access BPL devices operating at all frequencies at which they are capable.[30] This should be accomplished using the maximum possible BPL device output power and operational duty factor. In the event that the applicable limit is exceeded during measurements, the results of all *in situ* measurements at three representative sites at a given operating frequency may be adjusted downward by the difference

[30] For example, a BPL system that has 5 MHz bandwidth and can be tuned between 5 MHz and 30 MHz would be measured while tuned to 5 MHz, 10 MHz, 15 MHz...and 30 MHz. This principle should not be confused with the requirement to adjust measurement frequencies throughout frequency ranges specified in §15.33.

between maximum output power and the maximum compliant power level that will be used operationally at that frequency.[31] Consistent with §15.15(b), the Access BPL equipment should be modified to prevent inadvertent Access BPL operation at power levels that may result in field strength that exceeds the applicable limits.

E. MEASUREMENTS BELOW 30 MHz SHOULD USE A CALIBRATED LOOP ANTENNA WITH AN APPROPRIATE MAGNETIC-TO-ELECTRIC FIELD CONVERSION FACTOR AND AN ELECTRIC FIELD ANTENNA SHOULD BE USED ABOVE 30 MHz

NTIA is continuing to study the conversion between levels of magnetic field strength measured with a shielded loop antenna and electric field strength when measurements are performed at a horizontal distance of ten meters. In the far-field of a radiated emission, the ratio of electric-to-magnetic field strength (*i.e.*, wave impedance) is 377 ohms.[32] However, in the near field, such as at the ten-meter recommended measurement distance, NTIA's work to date indicates that wave impedance may vary from 1 ohm to over 2,000 ohms at various locations. NTIA's on-going study of wave impedance is focusing on the six measurement locations where electric field strength is highest and it is not yet clear whether the magnetic-to-electric field strength conversion factor will differ significantly from the presently assumed value of 377 ohms. NTIA will report its analysis findings as soon as possible insofar as this conversion factor should be codified in this proceeding.

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[31] The requirement to perform *in situ* compliance measurements at three representative deployment sites should specify how the results are to be applied in order to achieve compliance with field strength limits.

[32] For example, consistent with "Ohms Law," to convert a measured magnetic field strength in dBμA/m to an associated electric field strength in dBμV/m in the far filed region, one would add 20 log (377 ohms), or 51.2 dB, to the measured magnetic field strength.

F. REPRESENTATIVE POWER LINES USED FOR BPL MEASUREMENTS SHOULD BE CAREFULLY SELECTED TO ENSURE THAT PEAK EMISSIONS ARE MEASURED

In light of the highly varied parameters and radiation properties of power lines, compliance measurements should address BPL devices installed on power lines that yield the highest levels of field strength. One or more highly-reflective impedance discontinuities likely should be included in the power lines at various distances from the BPL coupling point in order to ensure that all important standing wave conditions are generated at all frequencies.[33] NTIA is continuing its studies to identify power line features that cause the highest levels of field strength and believes that the results need not be presented in rules, *per se*. The findings of this study will provide guidelines rather than basic regulatory infrastructure.

G. CERTAIN ADDITIONAL MEASUREMENT PROVISIONS SUCH AS MEASUREMENT BANDWIDTH SHOULD BE MANDATORY FOR BPL

In the framework of Part 15, many compliance measurement provisions are cast as guidelines and within these guidelines certain ANSI and CISPR measurement procedures are incorporated by reference.[34] For example, a requirement to use a quasi-peak detector is specified as a rule, but the measurement bandwidth is two levels removed from rule status by virtue of incorporation by reference from guidelines. NTIA believes that the measurement bandwidth should be specified as a rule for BPL, specifically 9 kHz bandwidth at frequencies below 30 MHz and 120 kHz bandwidth at frequencies above 30 MHz. Likewise, use of the above recommended measurement height correction factor and limits for three- and ten-meter measurement distances should be embodied as rules. NTIA believes that the BPL compliance measurement provisions deemed most important to limitation of interference risks should be

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[33] *See* NTIA Phase 1 study, §§7.2 and 7.9, which provide a degree of guidance.

[34] *See, e.g.*, 47 CFR 15.35.

codified as rules rather than guidelines.

H. SPECTRAL POWER DISTRIBUTIONS OF BPL EMISSIONS SHOULD BE MEASURED AND INCLUDED IN THE MEASUREMENT REPORT

In the course of its BPL measurement campaigns, using a spectrum analyzer, NTIA was able to quickly distinguish Access BPL emissions from other signals and noise by virtue of advance knowledge of the BPL system modulation and multiple access parameters but no knowledge of the operating frequencies. Identification of In-House and Access BPL signals could be further facilitated by inclusion of measured spectral power distributions in the compliance measurement report, and such data may provide other unforeseen benefits. This will assist interference diagnosis independently of adjustments to the BPL system. However, as stated earlier, positive identification of BPL interference can be readily accomplished via telephone with the radio operator, and remote-control adjustment of BPL system frequency usage or a brief shut-down of BPL network elements. NTIA does not expect that any radio operator will ever need to diagnose suspected interference from BPL systems because this is the responsibility of the BPL operators.

VII. ACCESS BPL MAY WARRANT ITS OWN RULE PART OR SUB-PART OF PART 15

NTIA suggests presentation of Access BPL rules in a new, dedicated rule part because weaving the appropriate Access BPL provisions into Part 15 may yield unclear, confusing rules.[35] Under similar circumstances, the Commission established technical rules for cable television systems in a new rule part.[36] The rules proposed in the BPL NPRM and the additional

[35] Rules for In-House BPL should be established in Part 15 as suggested by the BPL NPRM.

[36] 47 CFR 76. Like Access BPL systems, cable television systems are unintentional radiators. Ideal cable systems radiate no emissions and imperfections result in signal leakage. In sharp contrast, ideal Access BPL systems radiate emissions, endemically, albeit unintentionally.

Access BPL provisions recommended in this pleading are substantial. Many of these rules are unique to Access BPL and others derive from existing rules with special adaptation:

- Certification by the Access BPL operator rather than the manufacturer is inconsistent with Part 15.
- Access BPL amounts to a service, and as such, many of the contemplated technical rules could be viewed as service requirements that are inconsistent with the scope of Part 15.
- Coordination procedures, coordination areas, excluded bands or exclusion zones needed for Access BPL are not presently specified in Part 15.
- BPL equipage requirements for power control, frequency tuning and notching, and shut-down are not presented in Part 15.
- Procedural requirements for elimination of interference from Access BPL systems do not exist in Part 15 rules for unintentional emitters.
- Certain Part 15 provisions should not be applied to Access BPL (*e.g.*, measurement on radials from the device under test, §15.31(f)(5)).
- Specifications of the BPL operator notification requirements are more detailed than those in Part 15 for power line carrier systems.
- Many new and substantially modified measurement provisions should be specified as rules for Access BPL:
    - a uniform ten-meter measurement distance, perhaps with a three-meter option, rather than various distances at different frequencies;
    - a 5 dB height correction factor;
    - measurement with the Access BPL system operating at all frequencies at which it is capable of operating;
    - interpretation of *in situ* measurement results from 3 representative sites;
    - magnetic-to-electric field strength conversion factor for near-field measurements at frequencies below 30 MHz;
    - specification of equivalent field strength limits for ten- and perhaps three-meters in lieu of distance extrapolations;
    - measurement of spectral power distributions;
    - specification of measurement bandwidths.

VIII. FURTHER REGULATORY ACTION MAY BE NEEDED AFTER ADDITIONAL STUDIES ARE COMPLETED AND ADDITIONAL EXPERIENCE IS GARNERED.

NTIA believes that the In-House and LV/MV Access BPL rules proposed in the BPL

NPRM and recommended by NTIA constitute an appropriate basis for rulemaking at this time. The Commission has authorized Access BPL operations only under experimental licenses even through existing rules for carrier current systems accommodate BPL. As the rulemaking drew closer, the Commission ceased granting geographically unlimited BPL experimental licenses. Now, it is time to adopt rules that will enable development and implementation of In-House and LV/MV Access BPL that are compatible with radio communications.

Other potential BPL issues can be revisited under future actions, if necessary. The BPL NPRM notes that In-House BPL measurement guidelines should be updated if warranted based on studies by the International Special Committee on Radio Interference ("CISPR"). NTIA has not studied Access BPL using HV transmission lines. In the interim, based on expressed frequency preferences and available studies, the In-House and Access BPL operating frequency range should be limited to 1,705 kHz to 80 MHz (minus excluded bands and areas).[37] Oversight of potential future ionospheric interference is needed, but NTIA concludes that this interference could occur only in the long-term and NTIA intends to monitor BPL deployment in order to predict the potential onset of such problems.

IX. CONCLUSION

NTIA recommends a number of refinements to the modified rules proposed for BPL systems and believes that the Commission's proposals as extrapolated herein will fully alleviate the concerns of all parties to this proceeding. NTIA believes that these rules will prove to provide a reasonable and safe approach to reducing interference risks from BPL systems and expediting effective provisions for elimination of interference from BPL systems. Because these

[37] Experimental licenses granted Access BPL use of 1.7-80 MHz and NTIA studied BPL only in that frequency range. Interference risks exist from xDSL and Cable TV at other frequencies, potentially complicating diagnosis and elimination of interference from BPL systems.

proposed rule modifications effect reductions in on-going interference risks, they should be placed into effect as soon as possible. Moreover, these rules create an environment in which BPL proponents can properly gauge investment risks and fulfill the protection requirements of radio communications.

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TECHNICAL APPENDIX
TO THE NTIA COMMENTS ON THE BPL NPRM

EXECUTIVE SUMMARY

In response to the Federal Communication Commission's BPL Notice of Proposed Rulemaking (NPRM), NTIA's Phase 1 study of Broadband over Power Line (BPL) systems summarized Federal Government usage of the 1.7 – 80 MHz frequency range, presented measurement and modeling results for BPL emissions, defined interference risks to radio reception in the immediate vicinity of overhead power lines used by Access BPL systems, suggested refinements to measurement guidelines applicable to BPL systems, and identified means for mitigating local interference should it occur.[1] NTIA identified a number of issues requiring further study during its Phase 2 investigation of BPL. A number of these issues are addressed in this technical appendix to NTIA's comments on the BPL NPRM: the recommended antenna height for measuring emission levels; an appropriate height correction factor for use with measurements performed at a height of 1 meter; where to measure emissions relative to the BPL device and the attached power lines; and the aggregation of BPL emissions via ionospheric propagation.

Numerical Electromagnetic Code (NEC) models of a variety of power line models show a substantial variability in the height at which the peak field strength occurs. This variability can be seen over frequency and power line topology. In all cases where the operating frequency is above 6 MHz, the peak field strength occurred at heights greater than 1 meter. Analysis of the difference between peak field strength at any height and the peak field strength at 1 meter, or "height correction factor," showed that 80% of the values are less than 4 to 6 dB. In light of these results, NTIA recommends that measurements be performed at a height of 1 meter and a height correction factor of 5 dB be applied.

NTIA found from the NEC power line models that the locations all along the length of the power line where the field strength is at its peak, both at heights of 1 meter and overall, vary widely. For any given power line configuration, at some frequencies the peak occurs adjacent to or near the BPL device, while at other frequencies the peak occurs at substantial distances from the BPL device at an impedance discontinuity. There are also many frequencies where the field strength peaks at various distances along the power line. Thus, NTIA recommends that field strength measurements be performed at a 10 meter horizontal distance from an Access BPL power line, at points all along key segments of the power line where the maximum field strength from BPL emissions is expected to occur. In its ongoing Phase 2 study, NTIA will continue to investigate emissions along the power lines and recommend criteria for choosing representative segments of power lines to measure.

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[1] *Amendment of Part 15 regarding new requirements and measurement guidelines for Access Broadband over Power Line Systems*, Notice of Proposed Rule Making, ET Docket No. 04-37, February 23, 2004 ("BPL NPRM"); *Potential Interference from Broadband over Power Line (BPL) Systems to Federal Radiocommunications at 1.7 – 80 MHz*, NTIA Report 04-413, BPL NPRM, April 28, 2004 ("NTIA Phase 1 Study").

NTIA's worst-case oriented analysis of ionospheric propagation and aggregation of emissions from Access BPL systems indicates that interference via this mechanism will not occur in the near term. Considering realistically dispersed deployments of BPL systems, it would take hundreds of thousands of Access BPL devices operating under existing rules to cause a 1 dB increase in median noise. Under NTIA's recommended rule elements, chiefly the 5 dB height correction factor and power control, it would take millions of BPL devices to increase the median noise by 1 dB. NTIA will continue to analyze the long-term potential for interference due to aggregation via ionospheric propagation in its ongoing Phase 2 study.

In its Phase 1 study, NTIA analyzed the interference risks in terms of geographic locations where interference may occur to representative federal radio receivers due to outdoor, overhead Access BPL systems conforming to Part 15 rules for Class B digital devices above 30 MHz.[2] NTIA extended the interference risk analysis to include operation at Class A emissions limits above 30 MHz. Relative to operation under the Class B limit, the results for Class A show an increase of approximately 40 – 50% in the distances at which receiver operation at a given percentage of locations would experience a given noise floor increase. NTIA evaluated the effectiveness of its recommendations for a measurement height correction factor and found that it only slightly reduces interference risks for nearby land-mobile receivers. After applying the height correction factor, most locations within 15 meters of an Access BPL power line will experience a noise floor increase of 10 dB or more at operating frequencies between 1.7 MHz and 30 MHz. To further protect land-mobile operations, other risk reduction techniques should be employed, such as power control and avoidance of use of mobile service frequencies in physically adjacent Access BPL network elements. NTIA will further investigate these recommendations in its ongoing Phase 2 study.

NTIA will continue to investigate these and other issues identified in its Phase 1 report as requiring further study.[3] These include: determination of the equivalent field strength limits for the FCC's proposed ten meter measurement distance that reflects realistic decay of BPL signal strength with distance; the ratio of electric field to magnetic field below 30 MHz for suitable estimation of the electric field with a loop antenna in the near field; the protection requirements for sensitive or critical frequencies used by the Federal Government; and extending the interference risk analysis to include any resulting recommendations to enhance the Commission's Part 15 rules applicable to BPL systems.

[2] *See* NTIA Phase 1 Study, §6.

[3] *Id.* at §9.4.

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INTRODUCTION

1.1 BACKGROUND

NTIA's Phase 1 study of Broadband over Power Line (BPL) systems summarized Federal Government use of the 1.7 – 80 MHz frequency range, presented measurement and modeling results for BPL emissions, defined interference risks to radio reception in the immediate vicinity of overhead power lines used by Access BPL systems, suggested refinements to Part 15 measurement guidelines applicable to BPL systems, and identified means for mitigating local interference should it occur. Propagation and aggregation of emissions from BPL systems and the associated BPL deployment models were suggested as issues requiring further study.

Critical review of the assumptions underlying the BPL interference risk analyses revealed that compliance measurement procedures rather than field strength limits are the leading cause of high perceived interference risks. As applied in current practice to BPL systems, Part 15 measurement guidelines do not fully address certain unique characteristics of BPL radiated emissions. NTIA recommended the following supplemental BPL compliance measurement guidelines that derive from existing Part 15 measurement guidelines:

- Measurement of emissions from both the BPL devices and power lines to which they are attached.
- Measurement of BPL systems exhibiting the maximum potential frequency reuse.
- Use of measurement antenna heights at or above the height of power lines, possibly in connection with an adjustment factor accounting for field strength levels at other heights.
- Measurement at a distance of ten meters from the BPL device and power lines.
- Application of a distance extrapolation factor that reflects the radiation characteristics of BPL systems.
- Measurement of emissions with the BPL devices variously tuned to all frequencies at which it is capable of operating.
- Below 30 MHz, measurement using a calibrated rod antenna or a loop antenna in connection with appropriate factors relating magnetic and electric field strength levels.
- Careful selection of representative BPL installations that produce the highest levels of radiated emissions.
- Controls available to the operator must not be capable of causing generation of field strength in excess of the limiting values.

NTIA suggested in its Phase 1 report to further study the effectiveness of these recommended supplemental measurement guidelines.

1.2 OBJECTIVE

The objectives of this technical appendix are to offer specific recommendations to enhance Part 15 measurement guidelines applicable to Access BPL systems, to expand upon the interference risk analysis provided in NTIA's Phase 1 study report to include an assessment of the effectiveness of NTIA's recommended height correction factor, and to evaluate the potential impact on federal radiocommunications due to ionospheric propagation and aggregation of BPL emissions.

1.3 APPROACH

NTIA analyzed BPL field strength to determine the measurement height corresponding to the peak field strength and a reasonable height correction factor to employ when conducting measurements at the current Part 15 measurement height guideline of 1 meter (Section 2). NTIA also analyzed the locations corresponding to peak field strength along the power line in response to the Commission's proposal in the BPL NPRM to perform measurements only at specific locations (Section 3).[4] NTIA evaluated BPL signal aggregation and ionospheric propagation to provide initial worst-case estimates of the potential increase in noise (Section 4). The interference risk analysis from NTIA's Phase 1 study was expanded to include operation employing current Part 15 Class A digital device emission limits for frequencies above 30 MHz and the risk reduction from NTIA's recommended measurement height correction factor (Section 5).

[4] BPL NPRM, Appendix C, at ¶2.b.2.

SECTION 2
ANALYSIS OF MEASUREMENT ANTENNA HEIGHT

2.1 INTRODUCTION

Most federal radio receiver antennas are located at heights above 2 meters. The limited measurements from the Phase 1 study indicated that the level of radiated emissions was greater at the height of the power lines than at a 1 meter height. In NTIA's Phase 1 study, preliminary NEC modeling yielded similar results, leading to a recommendation to measure BPL emissions with an antenna situated near the height of the power lines. As an alternative, NTIA recommended that measurements performed at a height of 1 meter include a correction factor to account for the greater field strength at greater heights.

2.2 POWER LINE MODELS

A number of power line models were created using the NEC software to gain a greater understanding of the effects various physical topologies might have on the electric fields radiated by BPL signals on power lines. The electric field strength results in any polarization, over a range of heights and at any position along the length of the power line model were then evaluated statistically.

NTIA evaluated nineteen different power line topologies to calculate three-axis electric field values in a vertical grid located 10 meters from the power line (FCC-proposed measurement distance in the BPL NPRM), at heights ranging from 1 to 20 meters in one meter increments. These calculations were made horizontally along the length of the modeled power lines in one-meter increments, and at frequencies from 2 to 50 MHz (in 2 MHz increments). Eighteen relatively simple power line topologies are listed in Table 2-1. The orientation of power line conductors for these topologies is depicted in Figure 2-1.

Table 2-1: Power line topologies used to model antenna measurement height

Model Name	Number of Wires	Wire Configuration	Multi-grounded neutral with 3 transformers	Wire Spacing
tri26	2	triangular-horizontal	not included	0.6 meters
tri210	2	triangular-horizontal	not included	1.0 meters
tri36	3	triangular-horizontal	not included	0.6 meters
tri310	3	triangular-horizontal	not included	1.0 meters
tri26n	2	triangular-horizontal	included	0.6 meters
tri210n	2	triangular-horizontal	included	1.0 meters
tri36n	3	triangular-horizontal	included	0.6 meters
tri310n	3	triangular-horizontal	included	1.0 meters
ver1	1	vertical	not included	n/a
ver26	2	vertical	not included	0.6 meters
ver210	2	vertical	not included	1.0 meters
ver36	3	vertical	not included	0.6 meters
ver310	3	vertical	not included	1.0 meters
ver1n	1	vertical	included	n/a
ver26n	2	vertical	included	0.6 meters
ver210n	2	vertical	included	1.0 meters
ver36n	3	vertical	included	0.6 meters
ver310n	3	vertical	included	1.0 meters

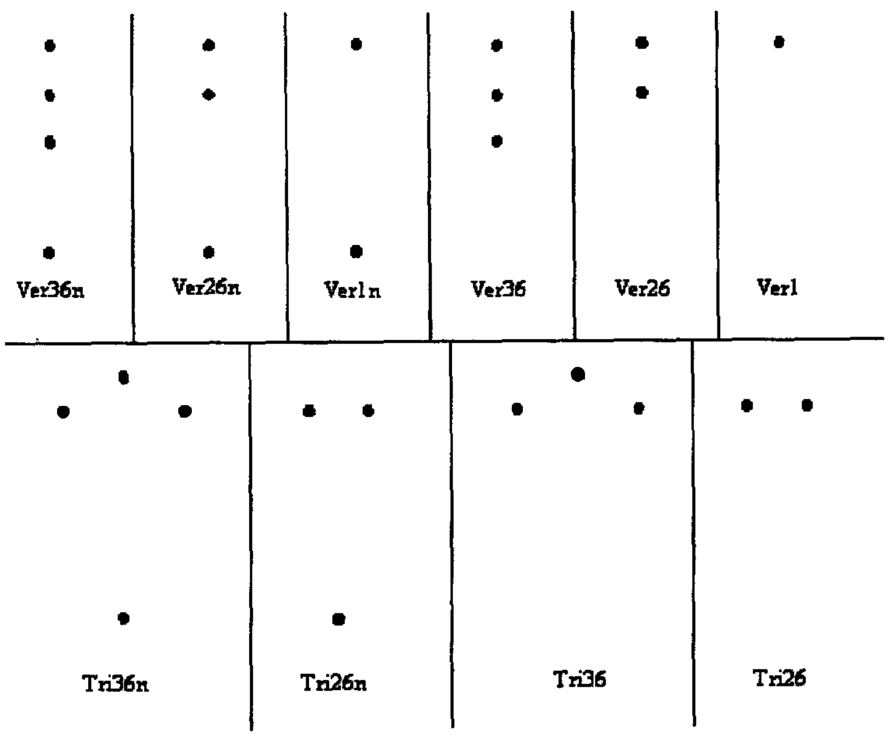

Figure 2-1: Power line topologies

All modeled power lines were 340 meters in length, and consisted of eight segments of catenary (hanging) wires (with catenary lengths of 43 meters each) between nine utility poles. The models were fed on a segment next to the model axis on one of the outside wires. All wires were assumed to be copper, and all models with neutral wires included three simulated distribution transformers wired between one of the phases and neutral, with 7.7 Ω of real impedance.[5] On the models with a neutral wire, the neutral was connected to ground at each transformer point (in the center of the model and at each end).

Vertical-alignment models were designed such that all wires (including the neutral, if any) were arranged in a vertical line. Triangular-horizontal models with three wires were designed with the middle wire 0.25 meter higher than the outer two. The neutral wire (if one was included) was centered under the phase wires.

NTIA also constructed an extensive NEC model based upon an actual MV distribution branch in one of the BPL deployment areas where NTIA conducted field measurements. This model was designed using power line maps as well as actual observation (Figure 2-2).

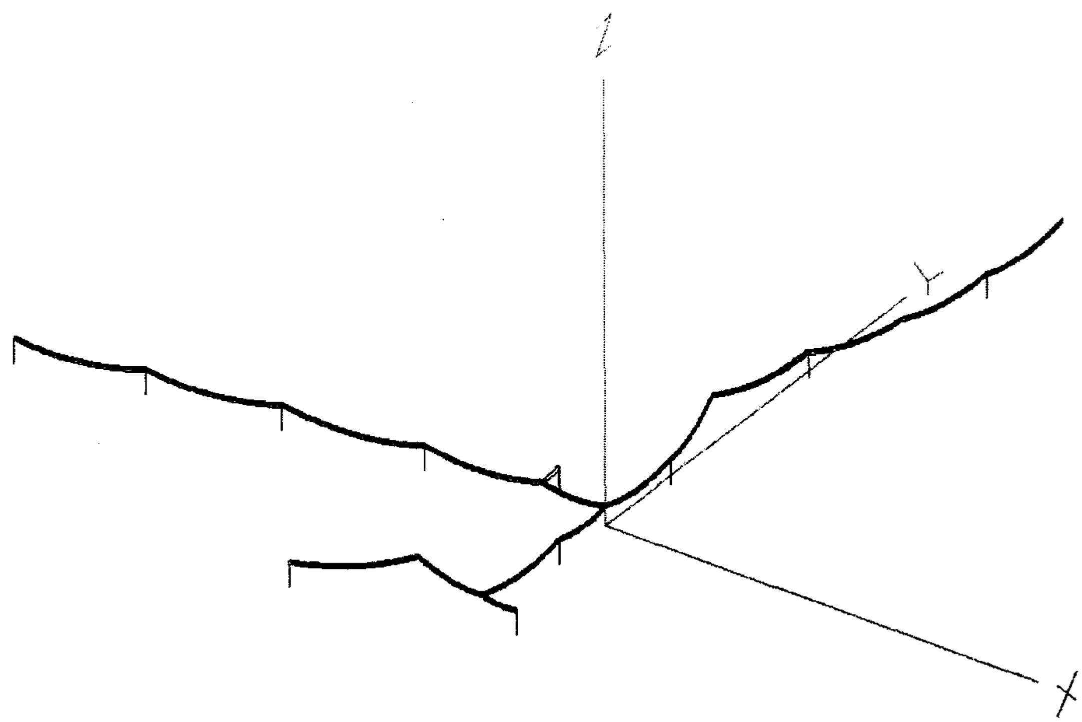

Figure 2-2: NEC model of actual power line carrying BPL signals

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[5] In actual systems, all transformer impedances vary widely, based upon varying loads in the system. However, preliminary calculations found that changing transformer impedances had little impact upon the results.

The model consisted of three-phase and multi-grounded neutral wiring. Included in the model are "risers" (connections of all three phases to underground wiring having a characteristic impedance of 30Ω), wire intersections, transformers and neutral grounds. Along most of the power line, the wiring topology is vertical, but at one pole (at a riser) it shifts to a horizontal-triangular configuration and then back to vertical.

The model covered an area of some 240,000 square meters (600m × 400m), and was designed (segmented and tested) at 4.303 MHz, 8.192 MHz, 22.957 MHz and 28.298 MHz (frequencies which corresponded with measurement frequencies in the field).

2.3 HEIGHT CORRESPONDING TO PEAK FIELD STRENGTH

Figures 2-3 through 2-20 show the heights where the peak electric field strength occurred over the frequency range of 2 – 50 MHz for the various power line topologies described in Section 2.2.

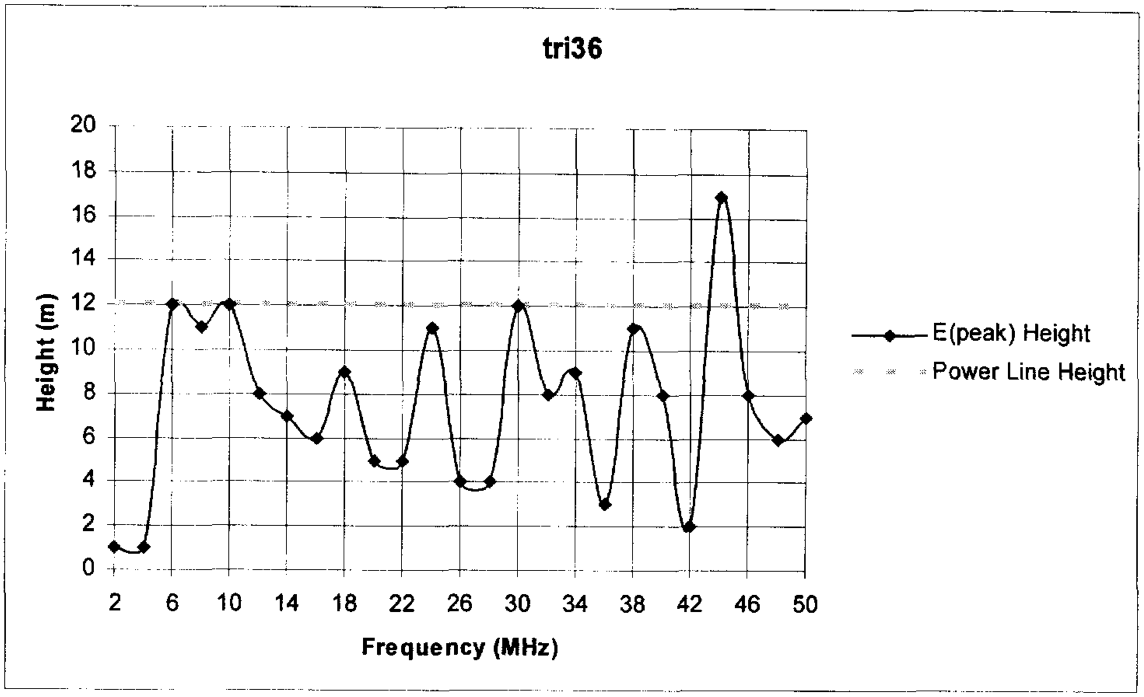

Figure 2-3: Height corresponding to peak field strength, vs. frequency – tri36 topology

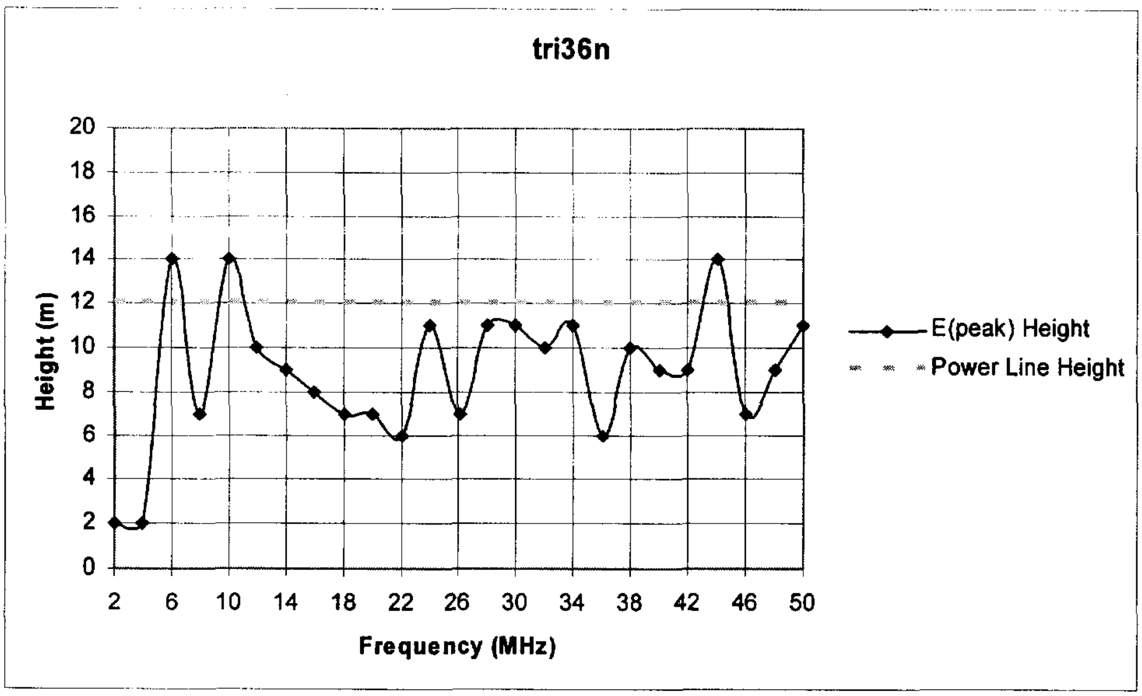

Figure 2-4: Height corresponding to peak field strength, vs. frequency – tri36n topology

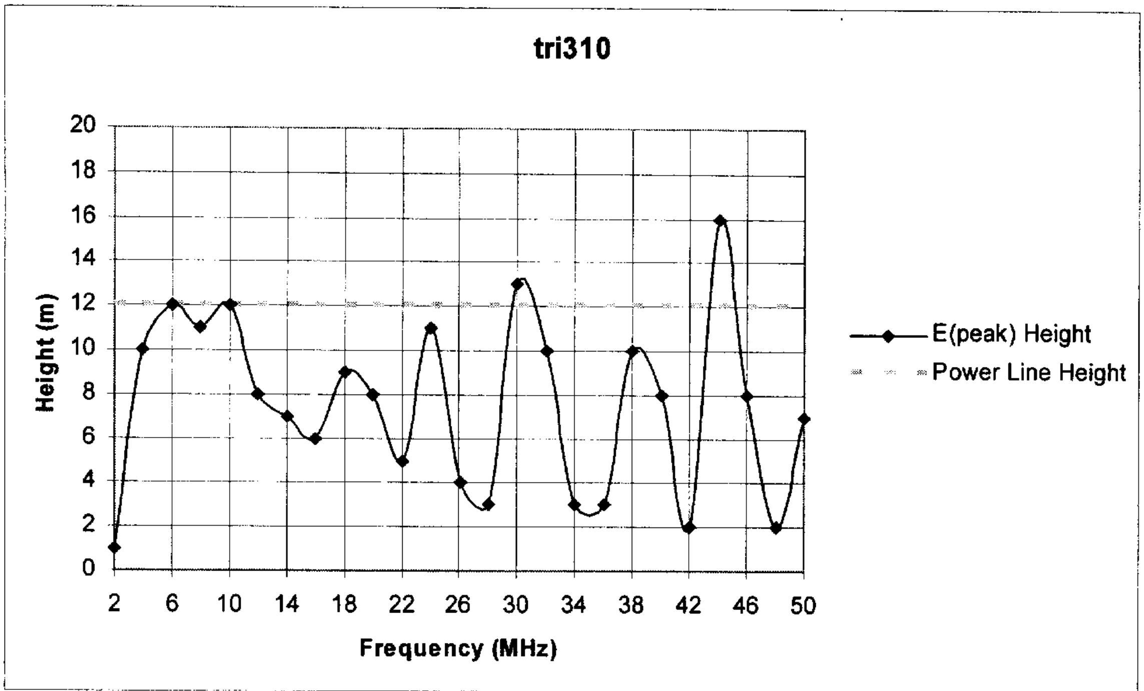

Figure 2-5: Height corresponding to peak field strength, vs. frequency – tri310 topology

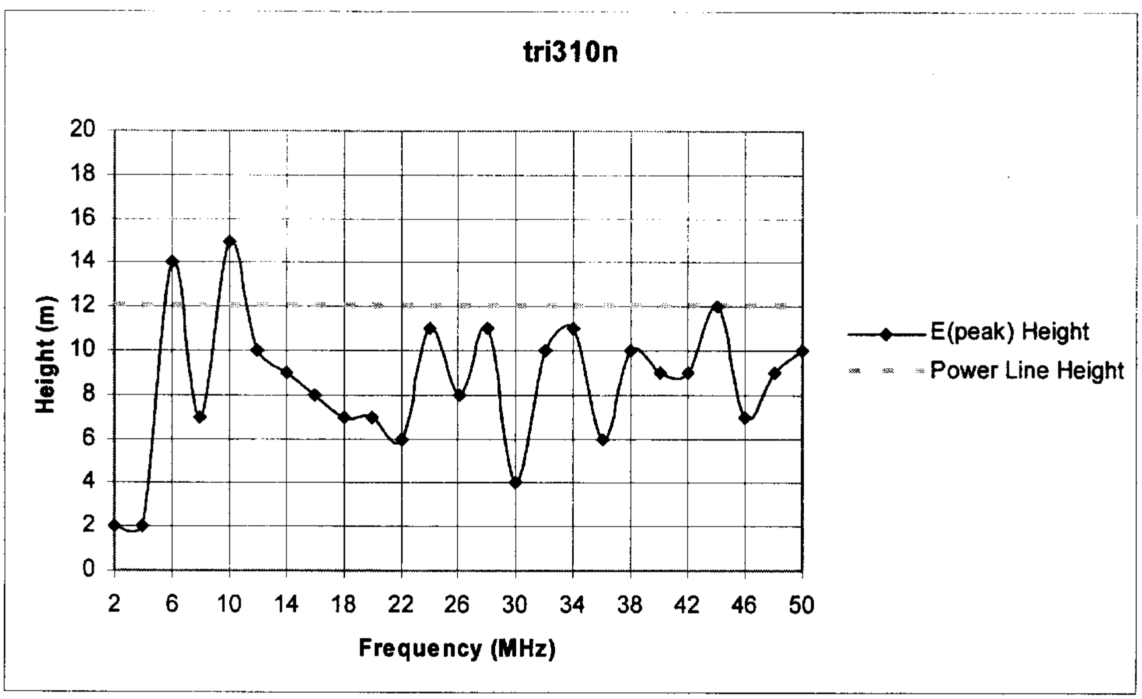

Figure 2-6: Height corresponding to peak field strength, vs. frequency – tri310n topology

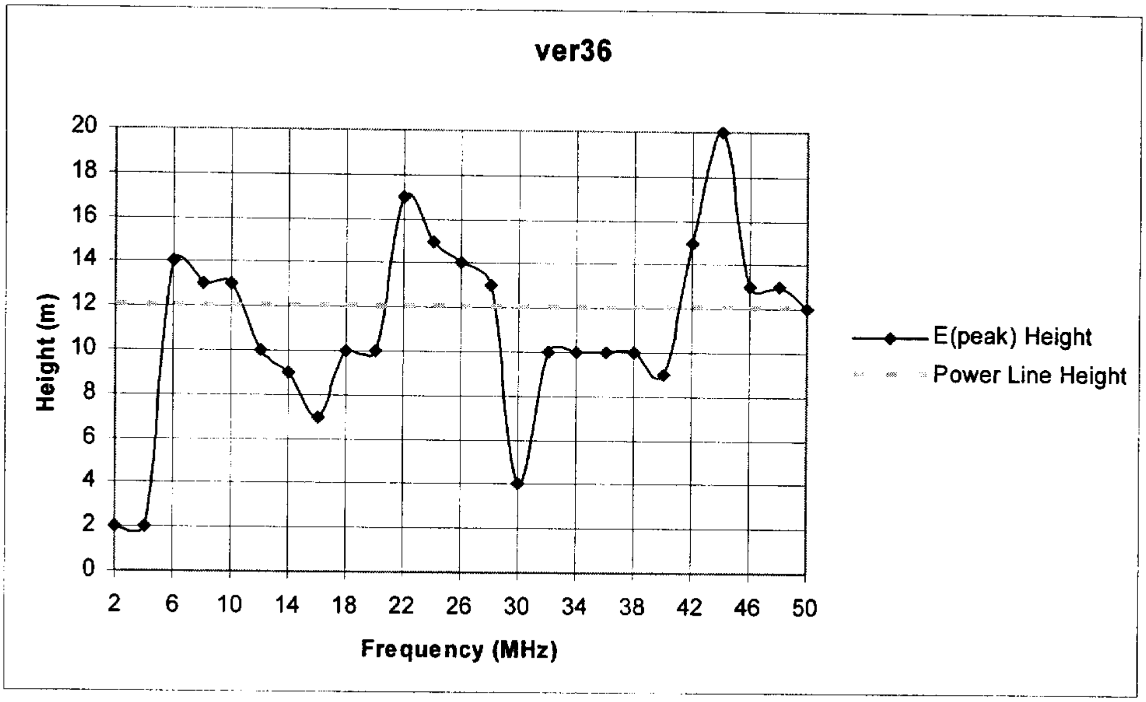

Figure 2-7: Height corresponding to peak field strength, vs. frequency – ver36 topology

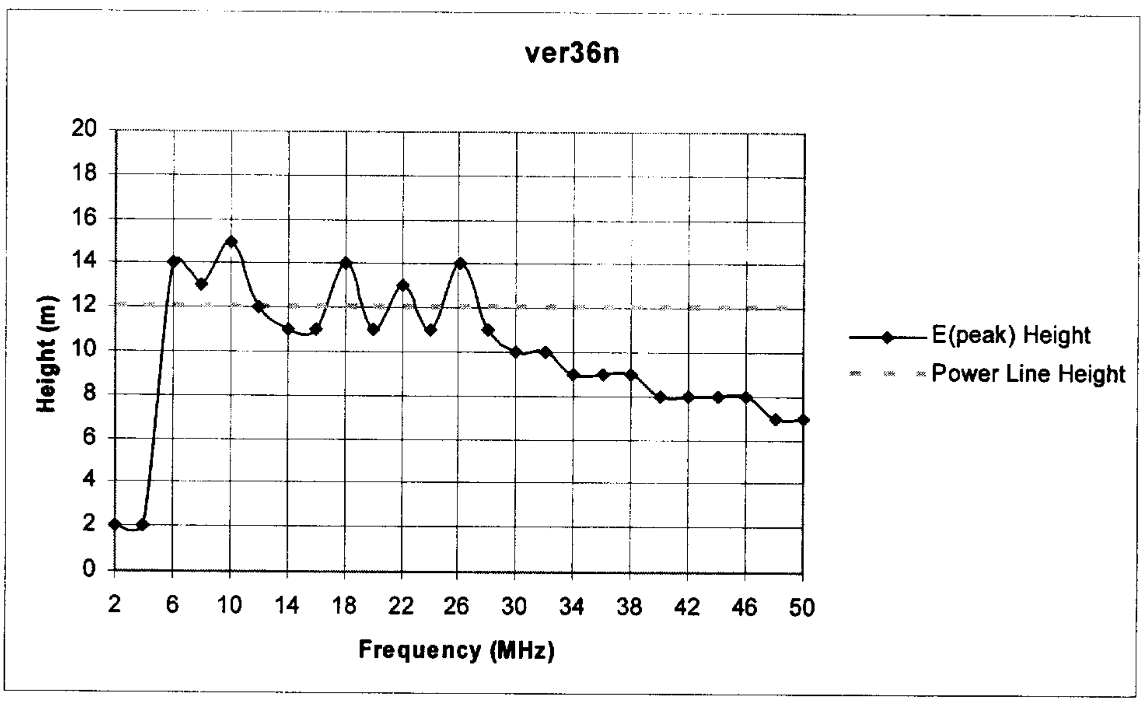

Figure 2-8: Height corresponding to peak field strength, vs. frequency – ver36n topology

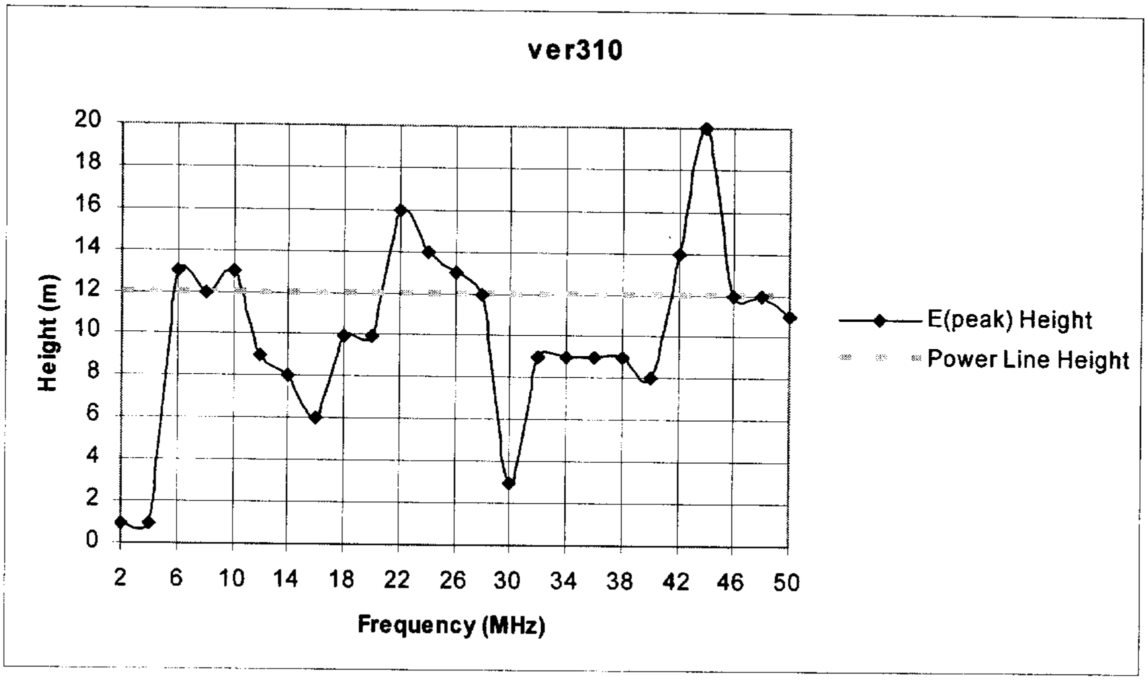

Figure 2-9: Height corresponding to peak field strength, vs. frequency – ver310 topology

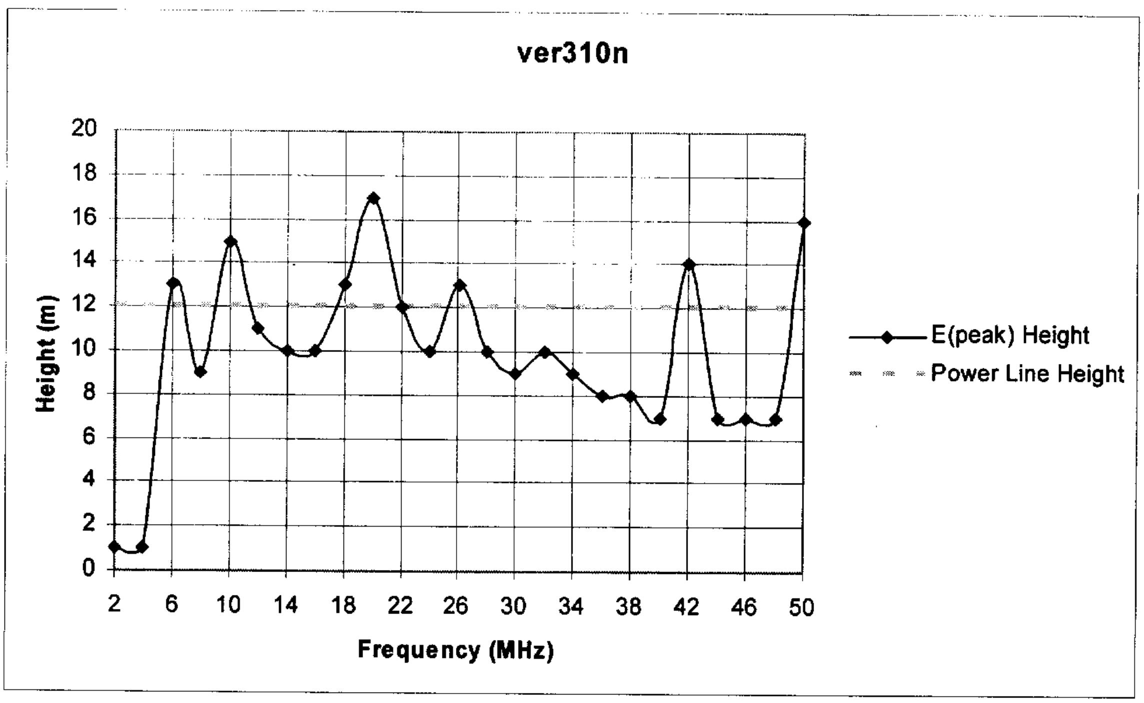

Figure 2-10: Height corresponding to peak field strength, vs. frequency – ver310n topology

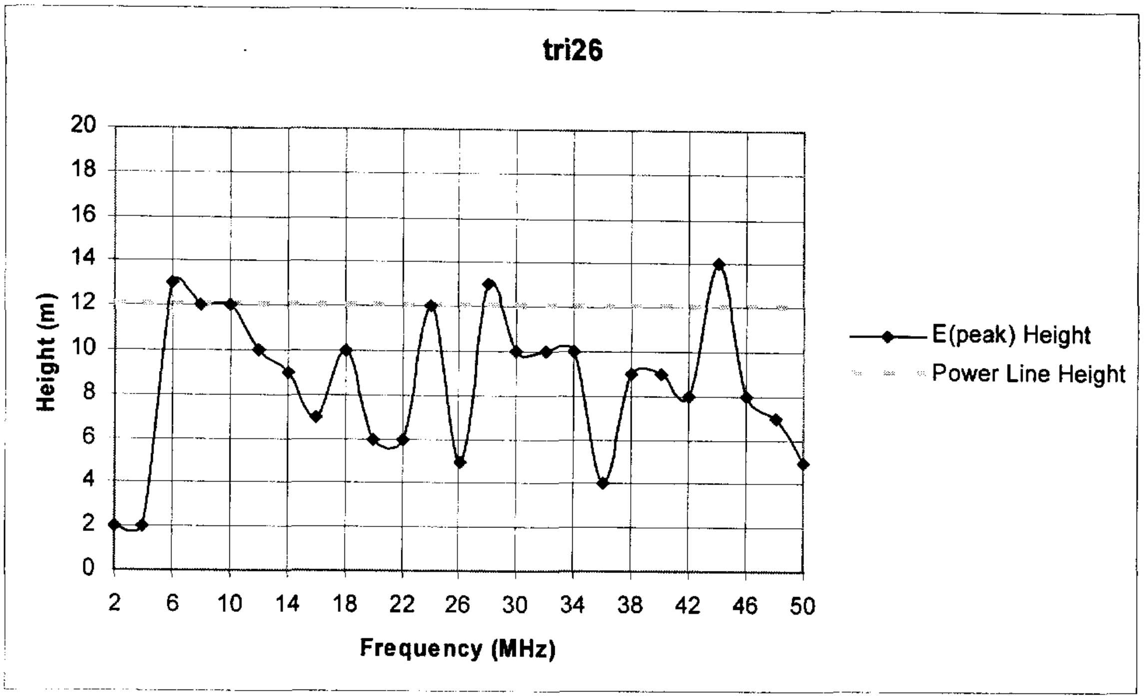

Figure 2-11: Height corresponding to peak field strength, vs. frequency – tri26 topology

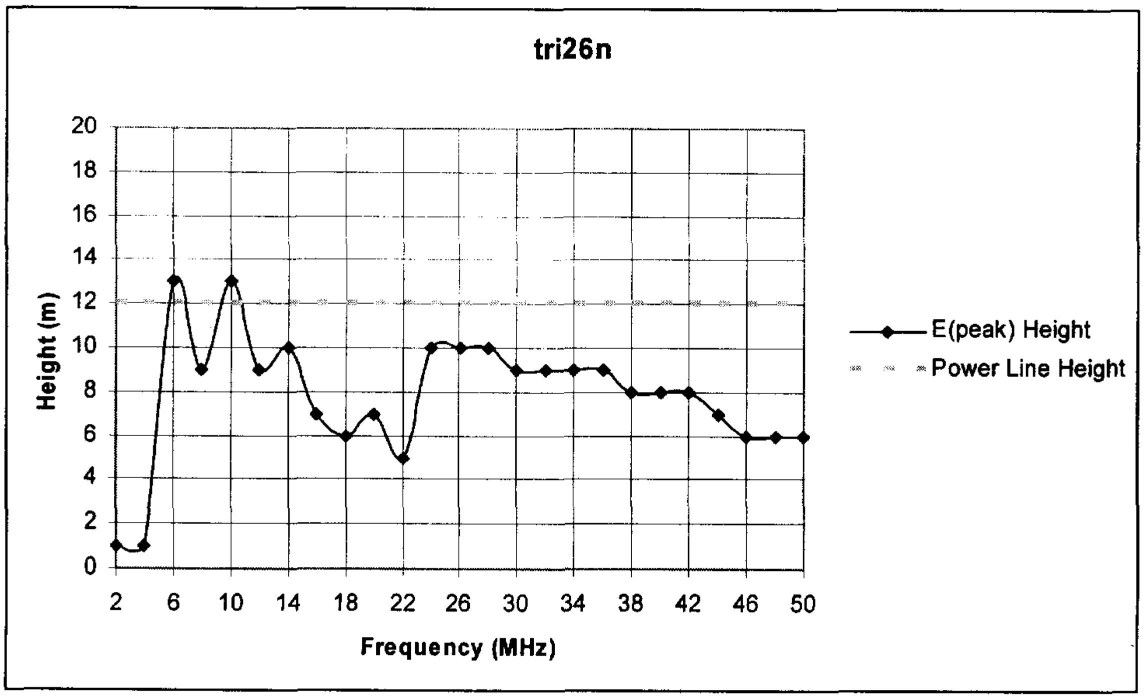

Figure 2-12: Height corresponding to peak field strength, vs. frequency – tri26n topology

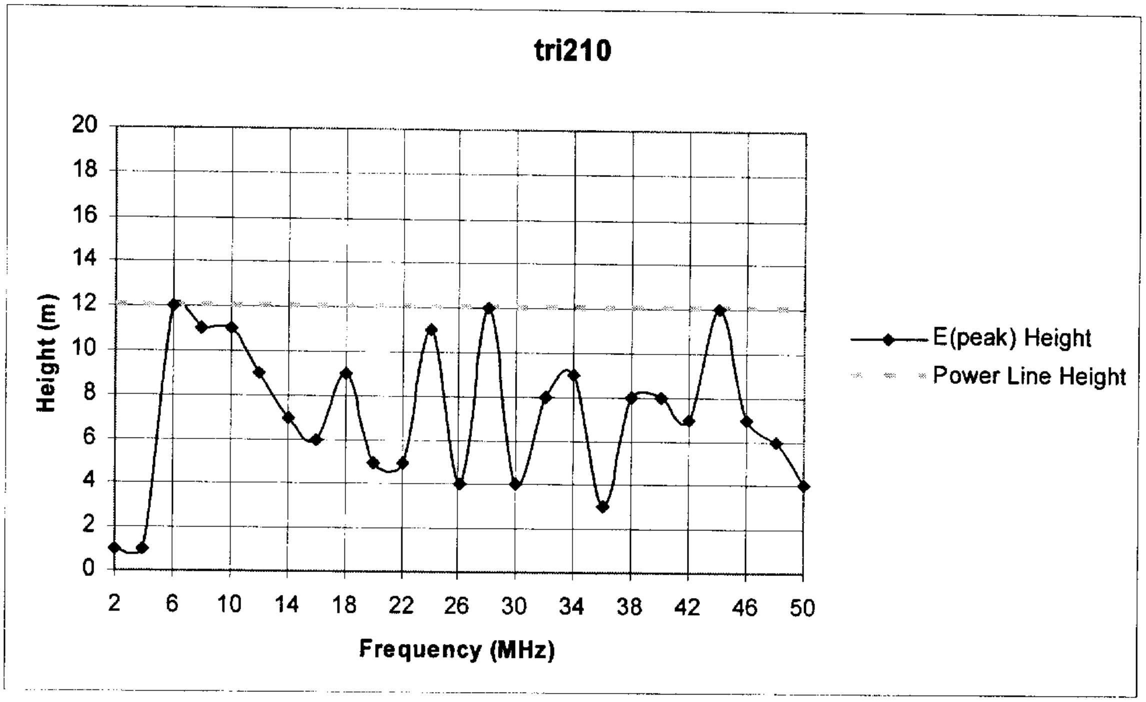

Figure 2-13: Height corresponding to peak field strength, vs. frequency – tri210 topology

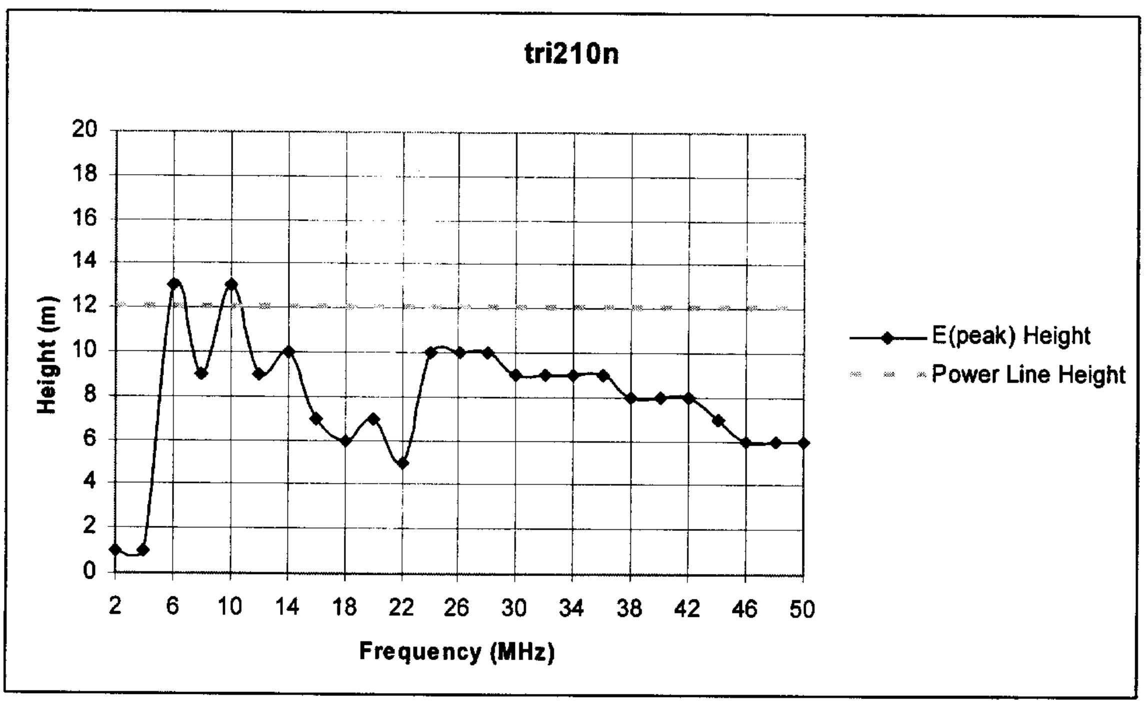

Figure 2-14: Height corresponding to peak field strength, vs. frequency – tri210n topology

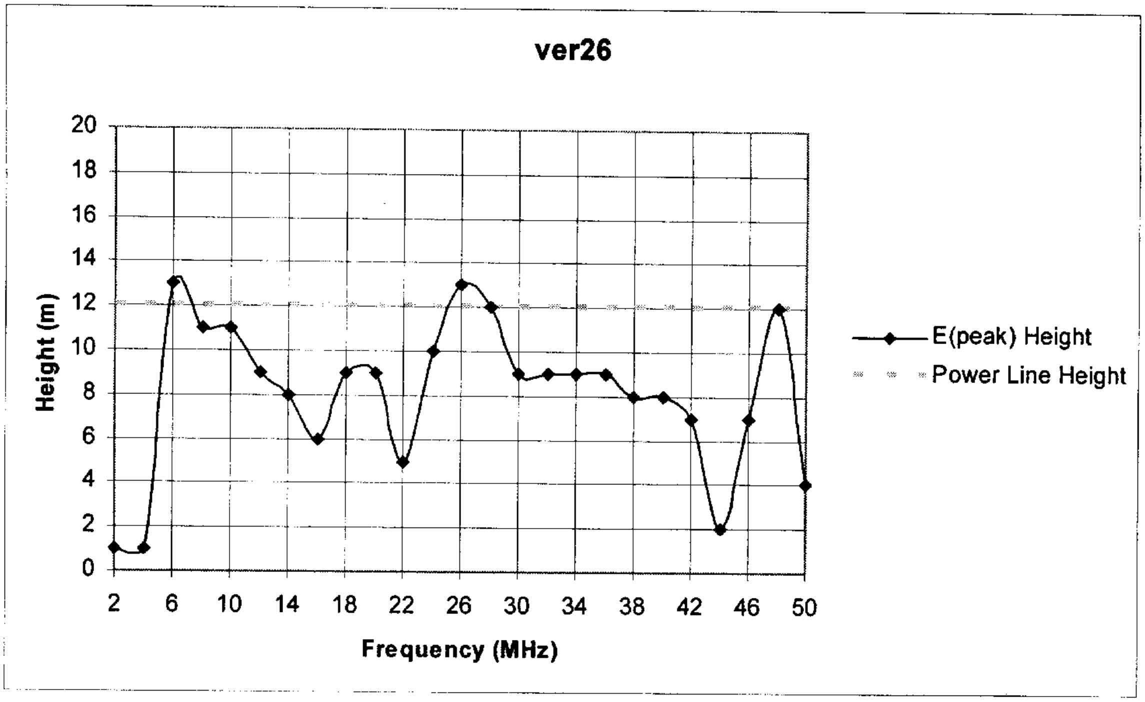

Figure 2-15: Height corresponding to peak field strength, vs. frequency – ver26 topology

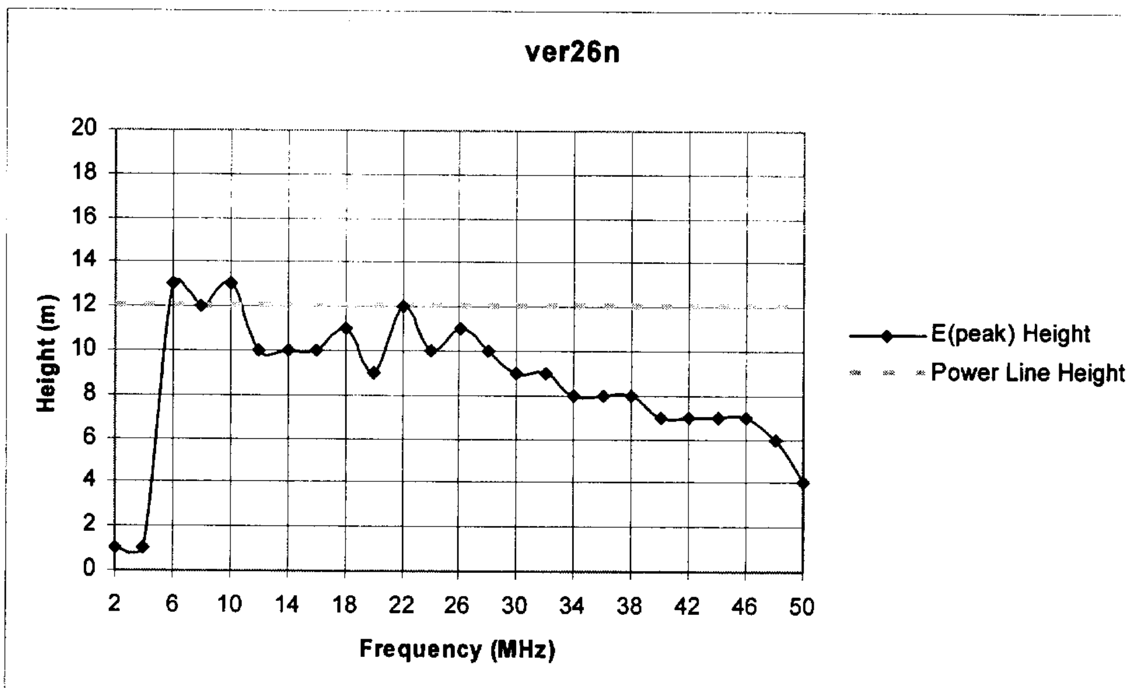

Figure 2-16: Height corresponding to peak field strength, vs. frequency – ver26n topology

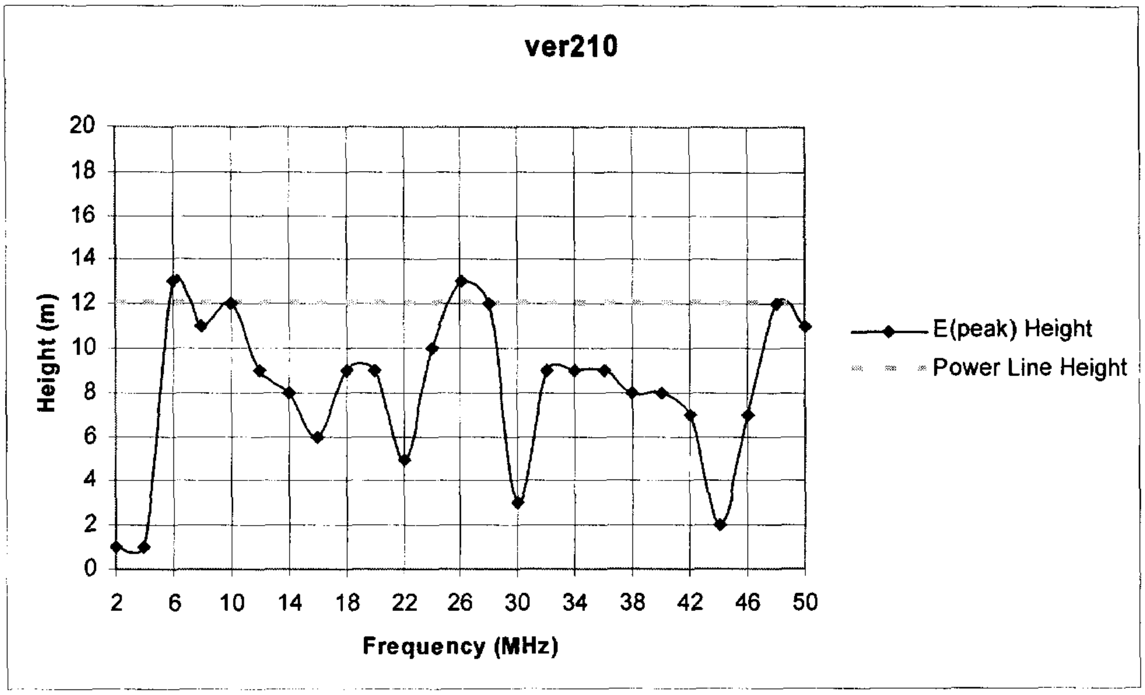

Figure 2-17: Height corresponding to peak field strength, vs. frequency – ver210 topology

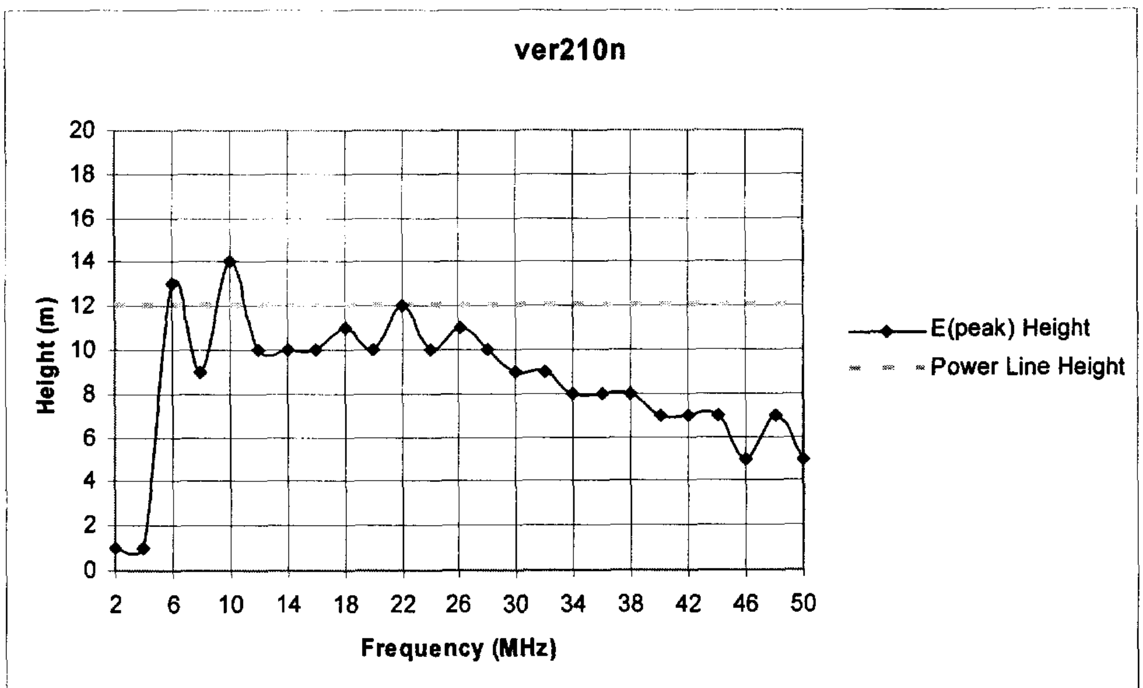

Figure 2-18: Height corresponding to peak field strength, vs. frequency – ver210n topology

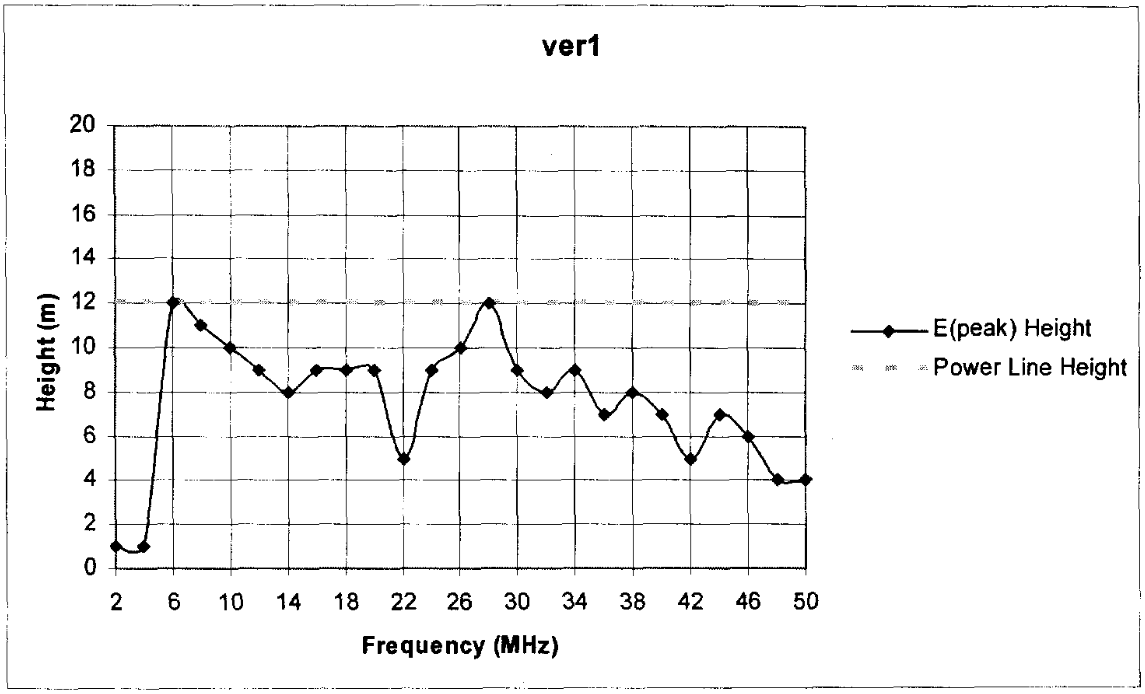

Figure 2-19: Height corresponding to peak field strength, vs. frequency – ver1 topology

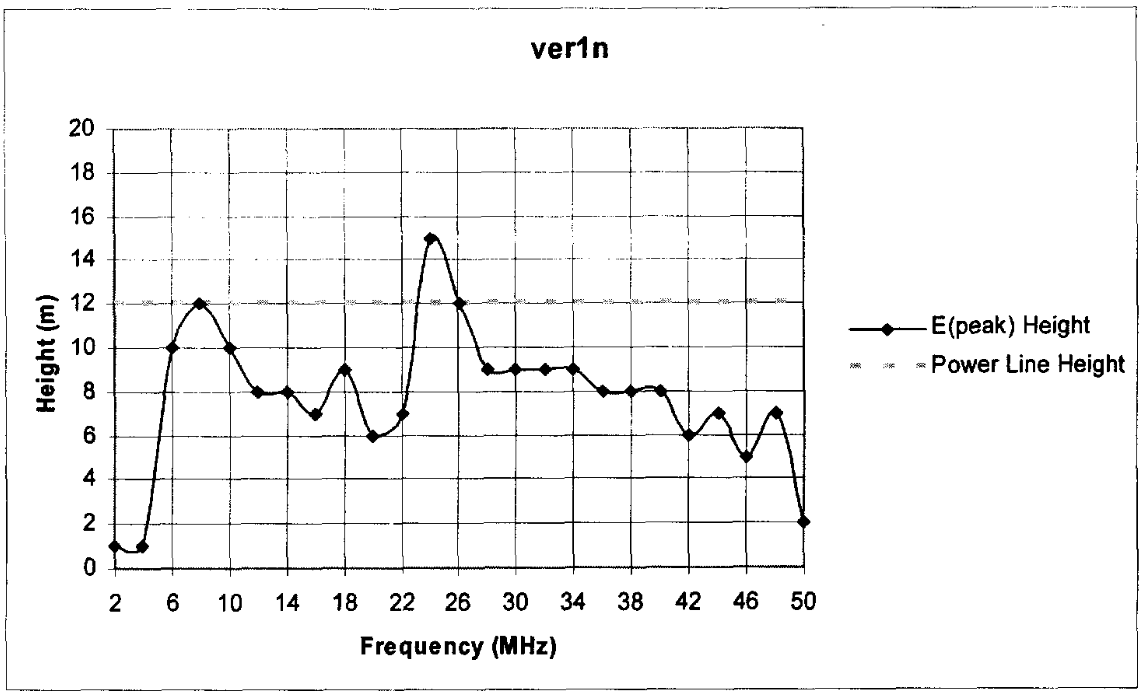

Figure 2-20: Height corresponding to peak field strength, vs. frequency – ver1n topology

For the model based upon an actual Access BPL power line structure (Figure 2-2), electric field simulations were performed at heights of 1 meter and 2 to 20 meters (in two-meter increments) for the entire area adjacent to the power line structure. The latter simulation was completed using NEC's "Near Field Along a Line" command ("LE"), which calculates electric fields for vectors along and perpendicular to a line. This more accurately depicts real-world measurement conditions in which measurements would be taken along these vectors. Figures 2-21 through 2-23 illustrate the variation in field strength in all three polarizations at 1 meter and at the height of the power lines (12 meters). Figure 2-24 shows the height corresponding to the peak field strength in any polarization at ten meters from the power line, for the four frequencies evaluated with this model.

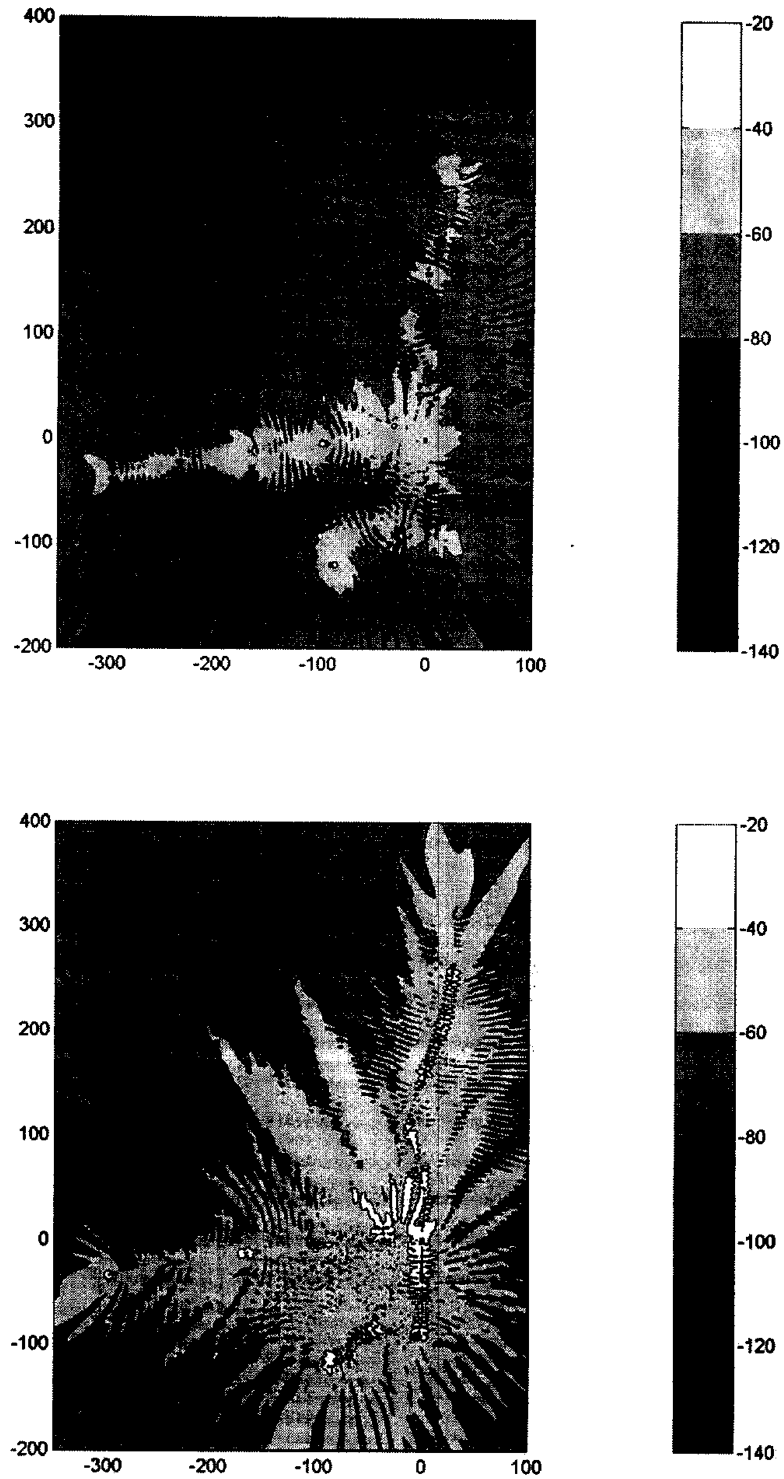

Figure 2-21: X-axis electric field values surrounding power line structure at 28.298 MHz. Top: 1 meter height. Bottom: 12 meter height. Axis values in meters; relative electric field values in dB.

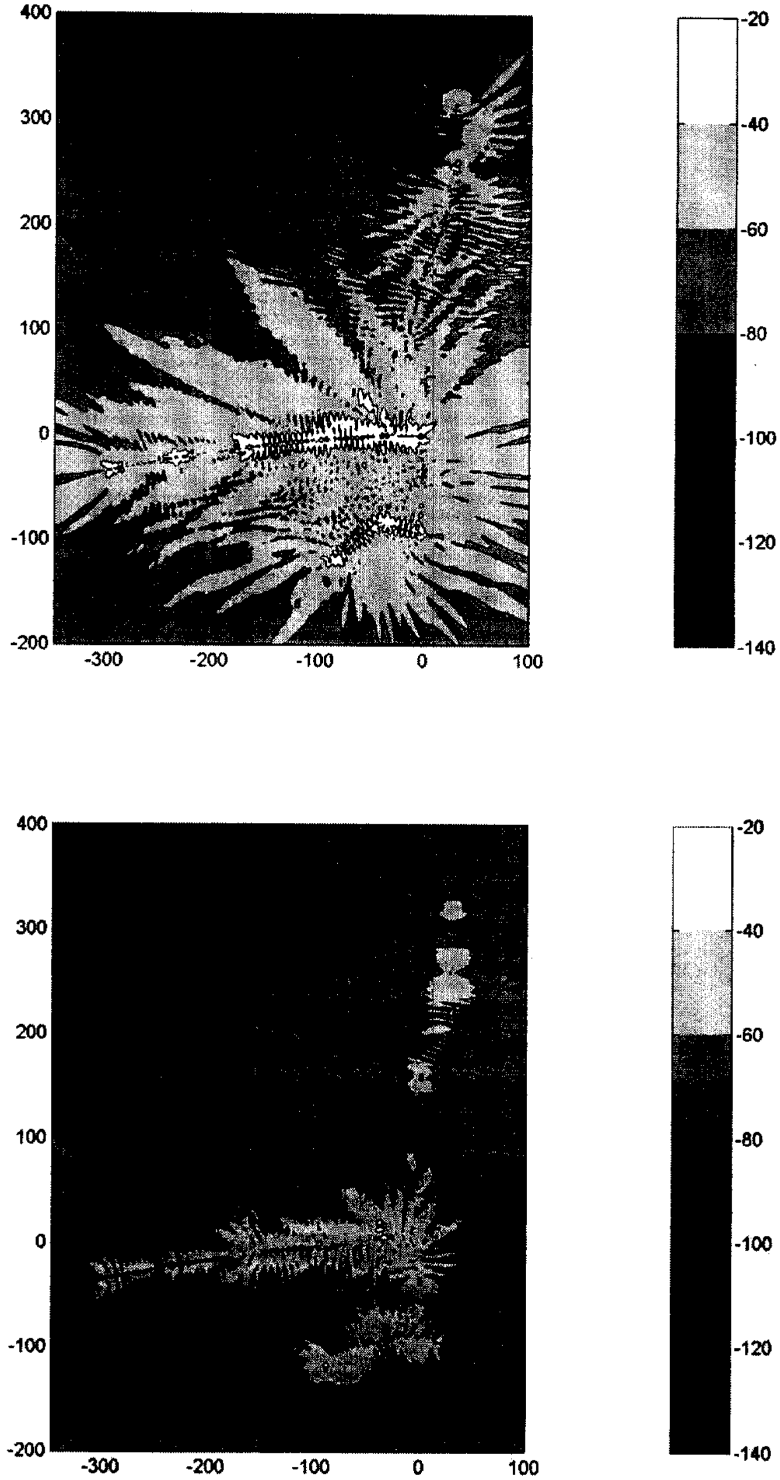

Figure 2-22: Y-axis electric field values surrounding power line structure at 28.298 MHz. Top: 1 meter height. Bottom: 12 meter height.

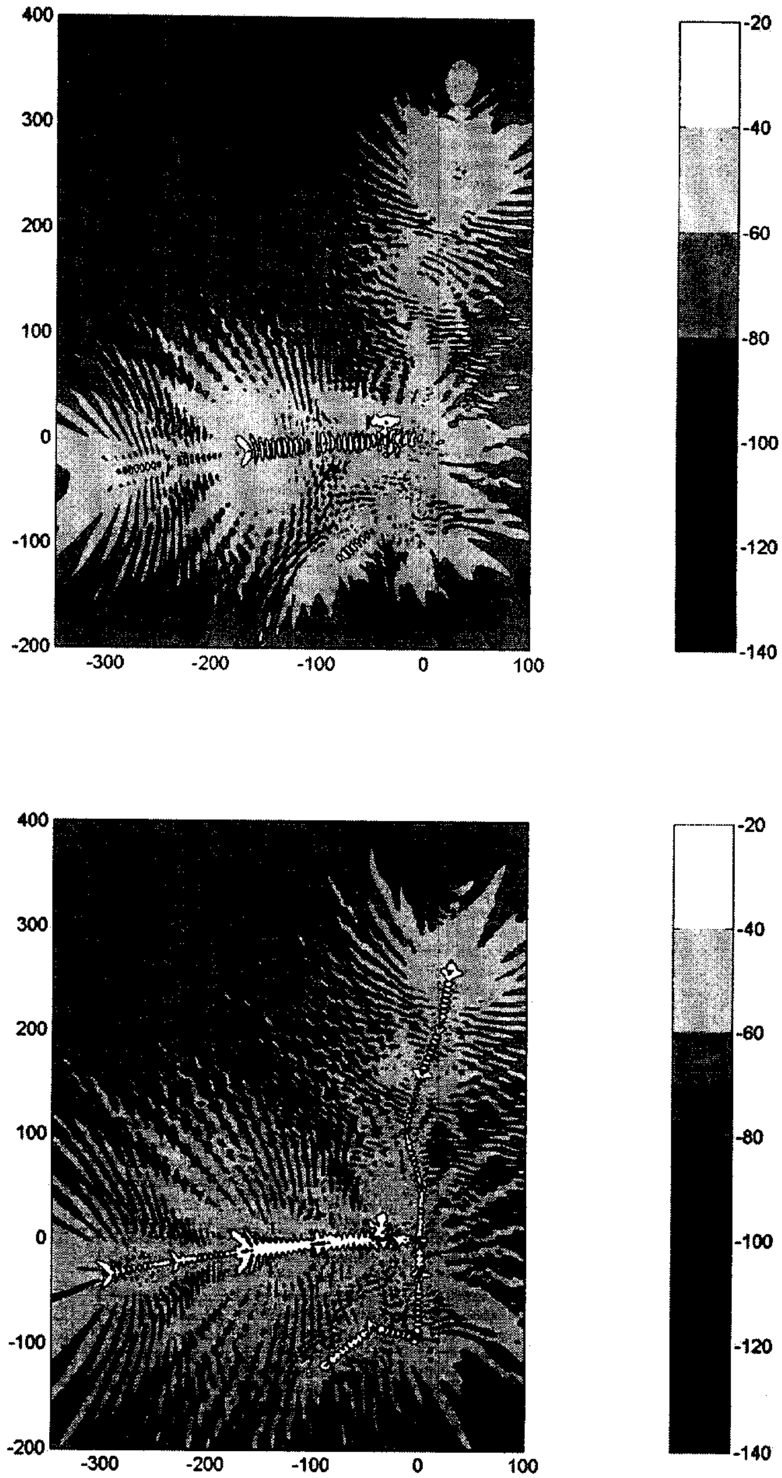

Figure 2-23: Z-axis electric field values surrounding power line structure at 28.298 MHz. Top: 1 meter height. Bottom: 12 meter height.

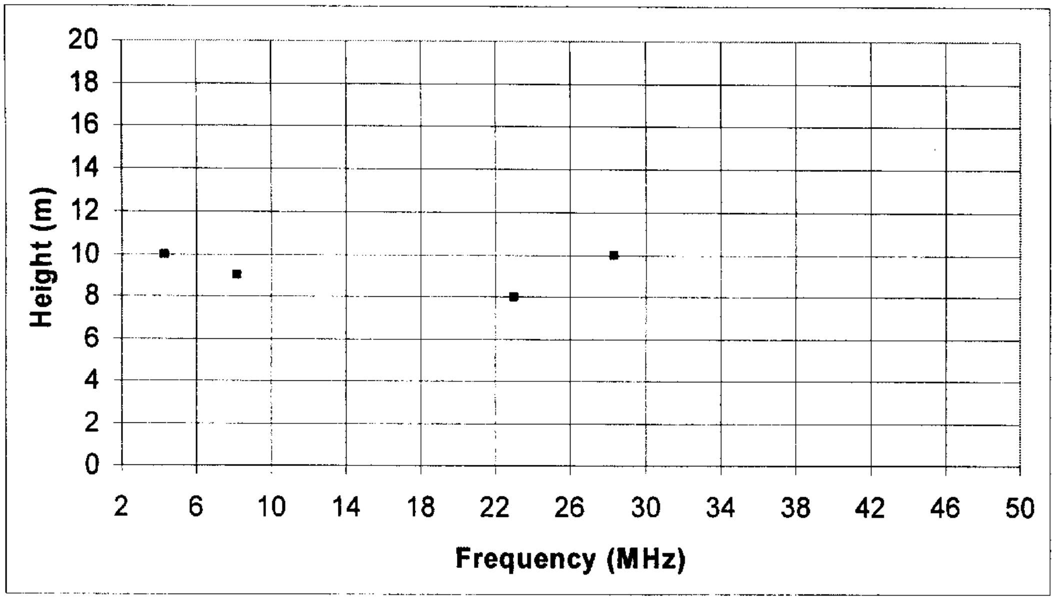

Figure 2-24: Height corresponding to peak field strength, vs. frequency for the power line model shown in Figure 2-2.

2.4 ANTENNA MEASUREMENT HEIGHT CORRECTION FACTOR

NTIA has found through measurements and simulations that existing Part 15 compliance measurements performed at an antenna height of 1 meter will likely underestimate the overall peak electric field strength of BPL emissions. Determination of peak field strength over all heights for Part 15 compliance measurement purposes can be accomplished either through direct measurement at various heights and directions, or by application of a correction factor to measurements made with a standard 1 meter antenna height. NTIA evaluated the above power line configurations using the NEC software to determine a suitable height correction factor when field strength measurements are performed at a 1 meter height.

Calculations of peak field strength *vs.* height for the eighteen simple power line models described earlier are shown in Figures 2-25 through 2-42. The peak electric field strength at each height was determined from the 80th percentile values of field strength along the length of the power line. The 80th percentile values eliminate the localized peaks that are unlikely to be encountered by a radio receiver randomly located in close proximity to an Access BPL power line. Use of the 80th percentile value is consistent with international measurement standards that seek 80% compliance with an 80% degree of confidence.[6]

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[6] *See e.g.*, Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement, CISPR 22:2003, ("CISPR 22"), Section 7.1.2 "The significance of the limits for equipment shall be that, on a statistical basis, at least 80% of the mass-produced equipment complies with the limits with at least 80% confidence."

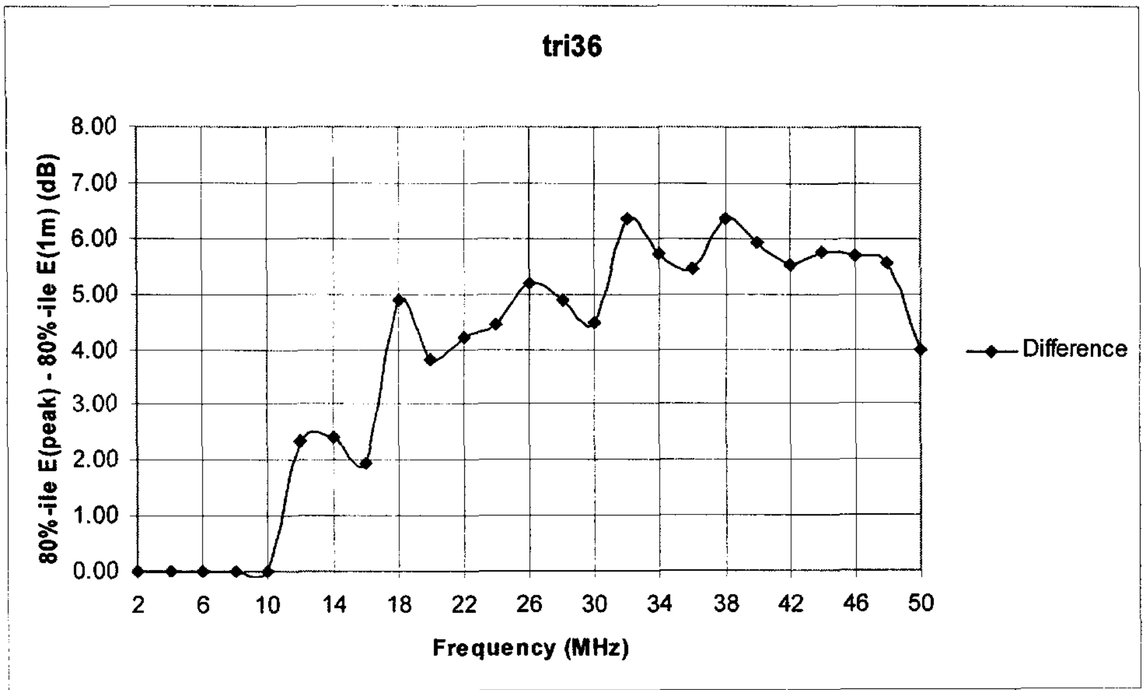

Figure 2-25: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; tri36 power line topology

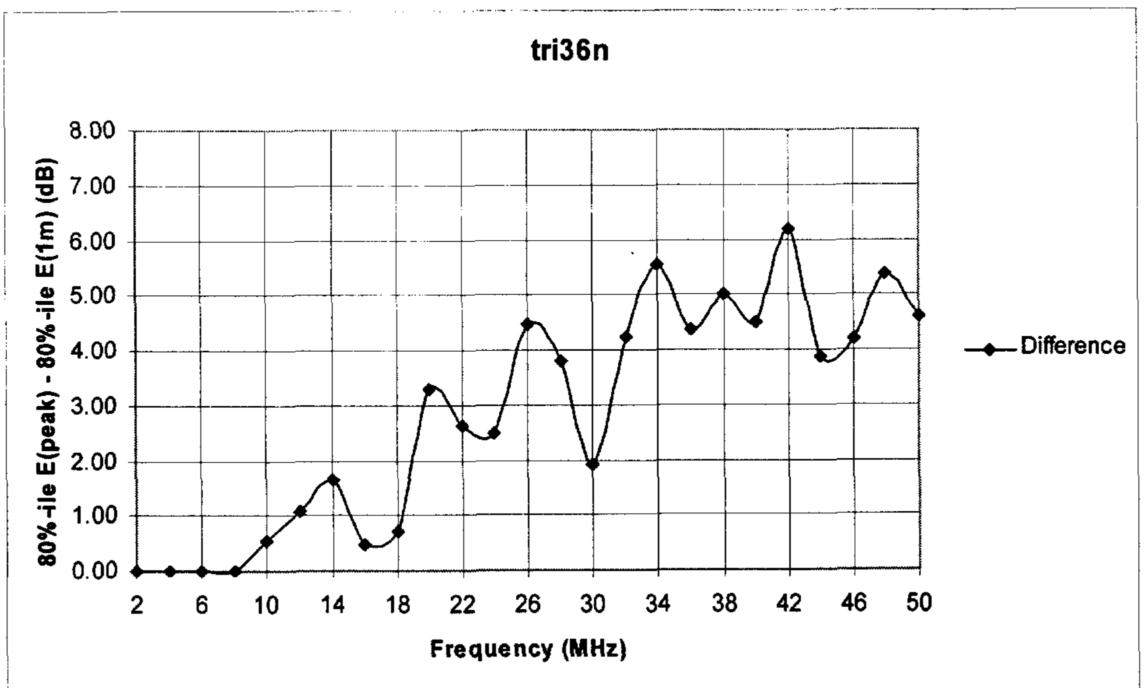

Figure 2-26: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; tri36n power line topology

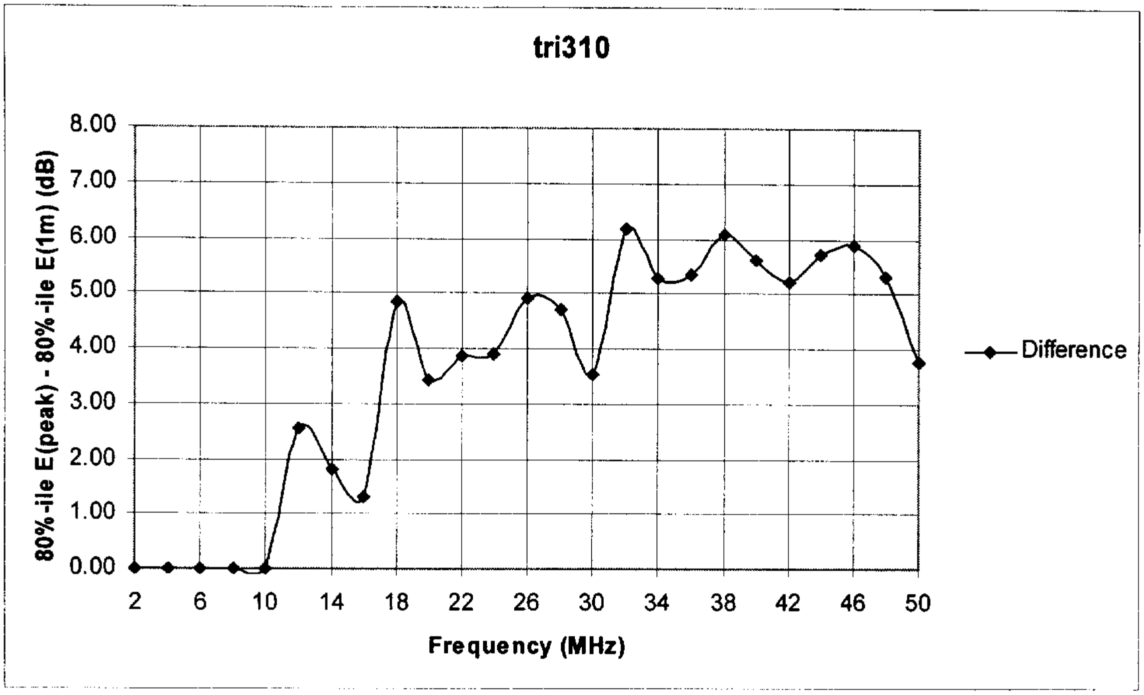

Figure 2-27: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; tri310 power line topology

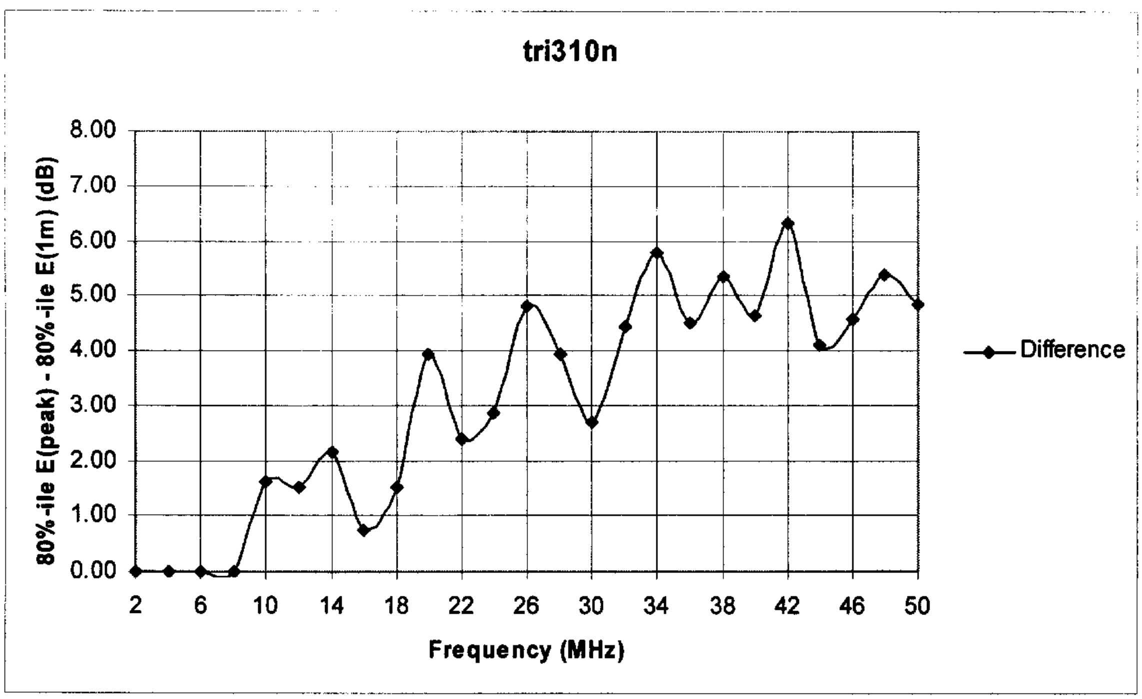

Figure 2-28: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; tri310n power line topology

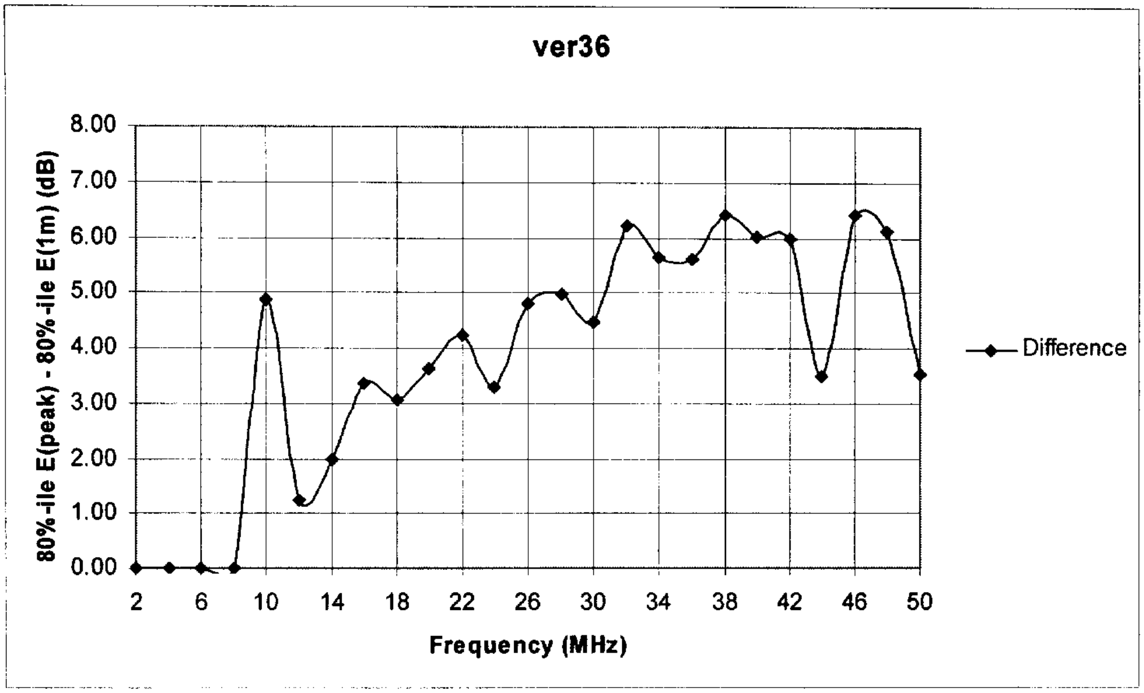

Figure 2-29: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver36 power line topology

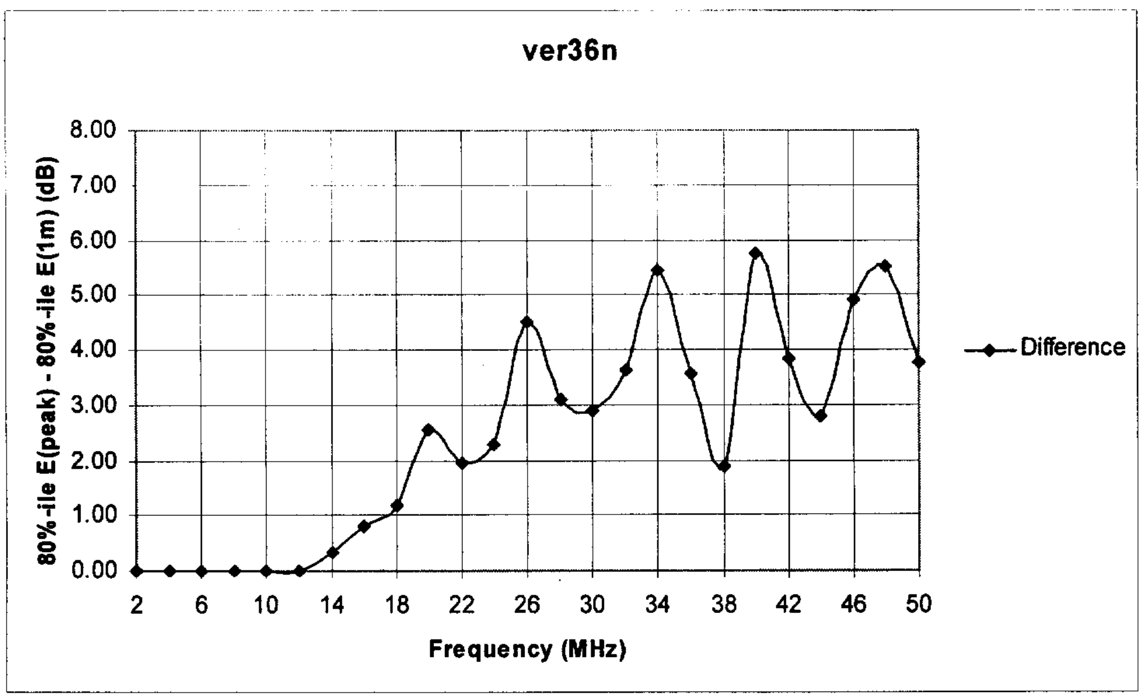

Figure 2-30: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver36n power line topology

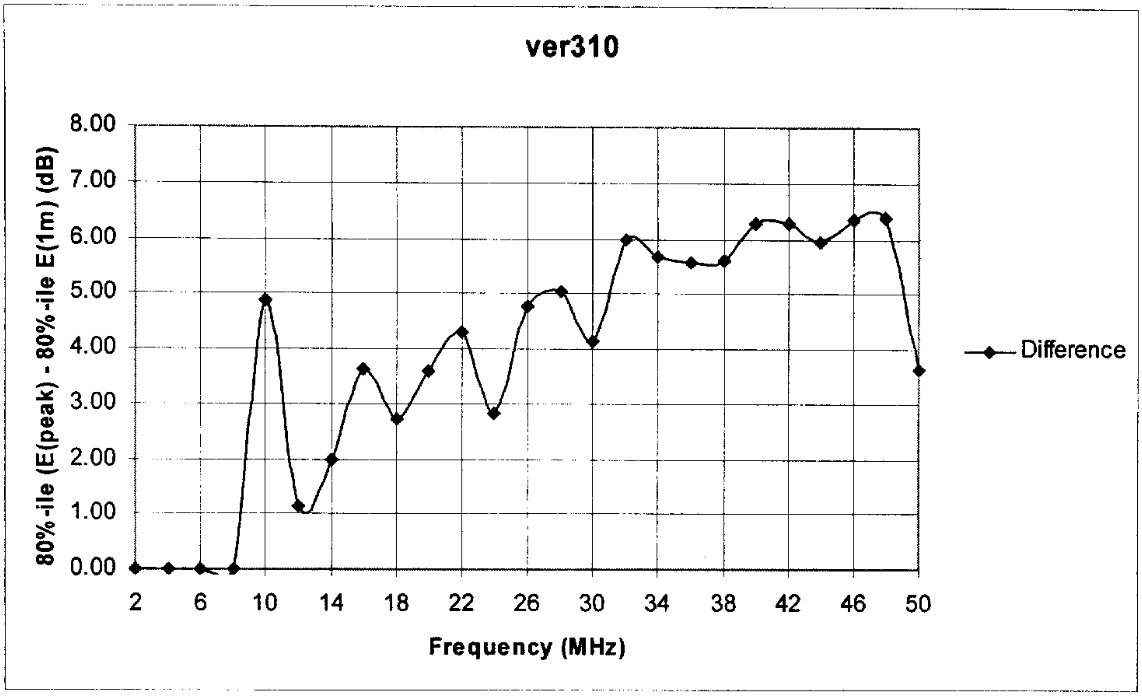

Figure 2-31: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver310 power line topology

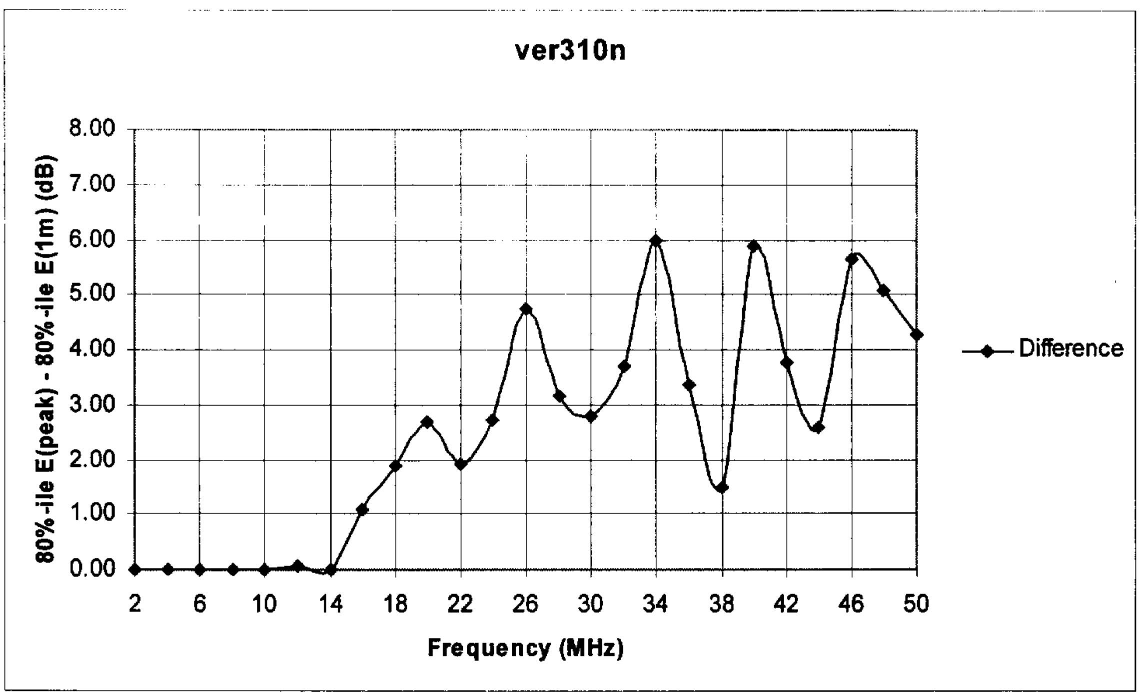

Figure 2-32: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver310n power line topology

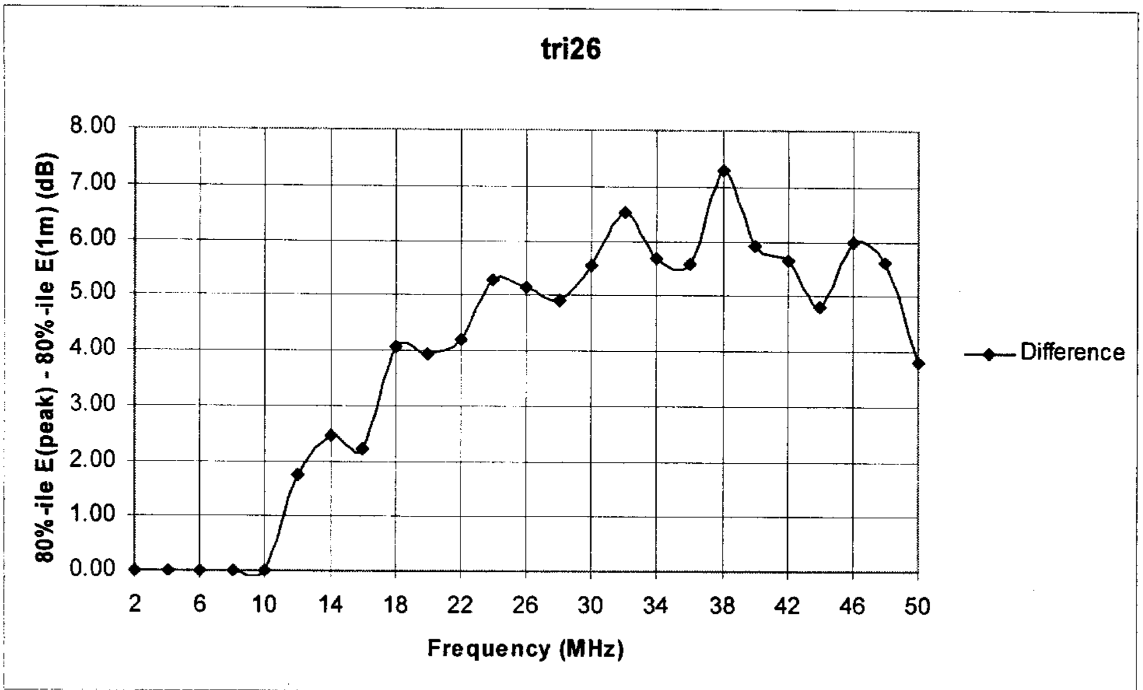

Figure 2-33: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; tri26 power line topology

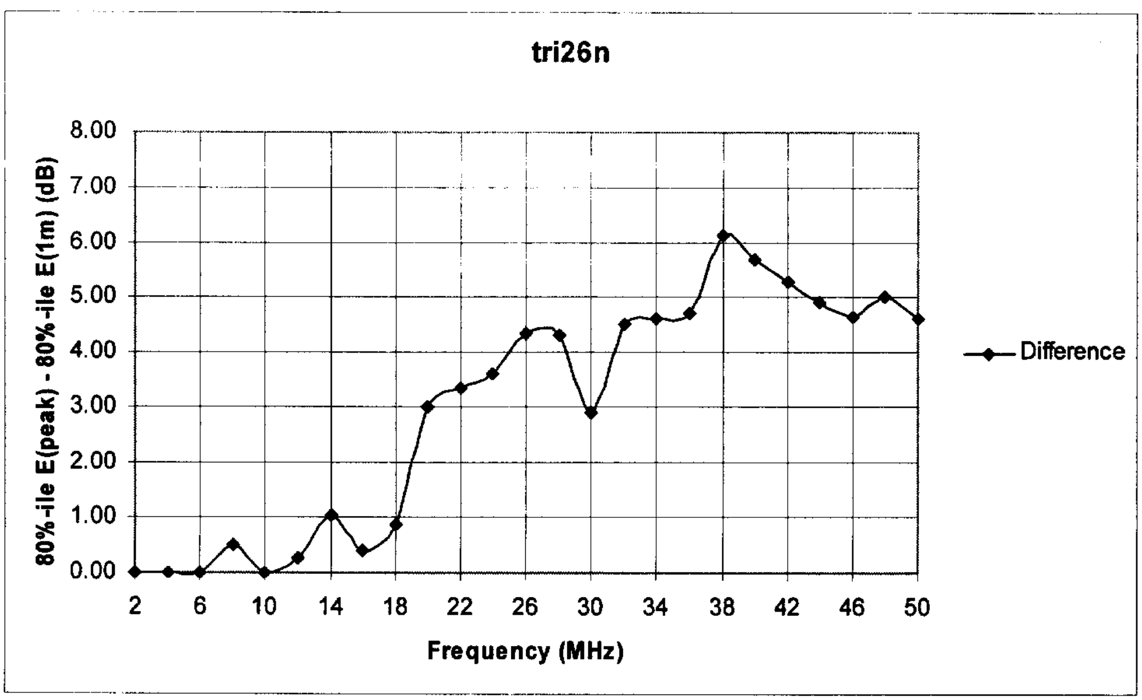

Figure 2-34: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; tri26n power line topology

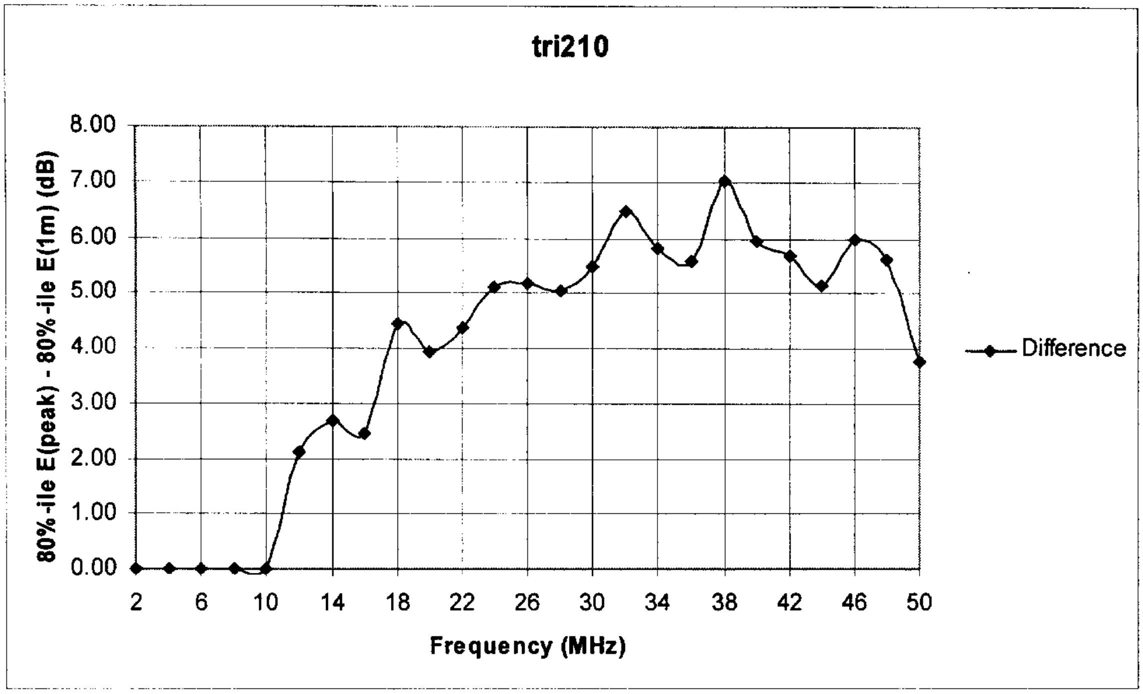

Figure 2-35: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; tri210 power line topology

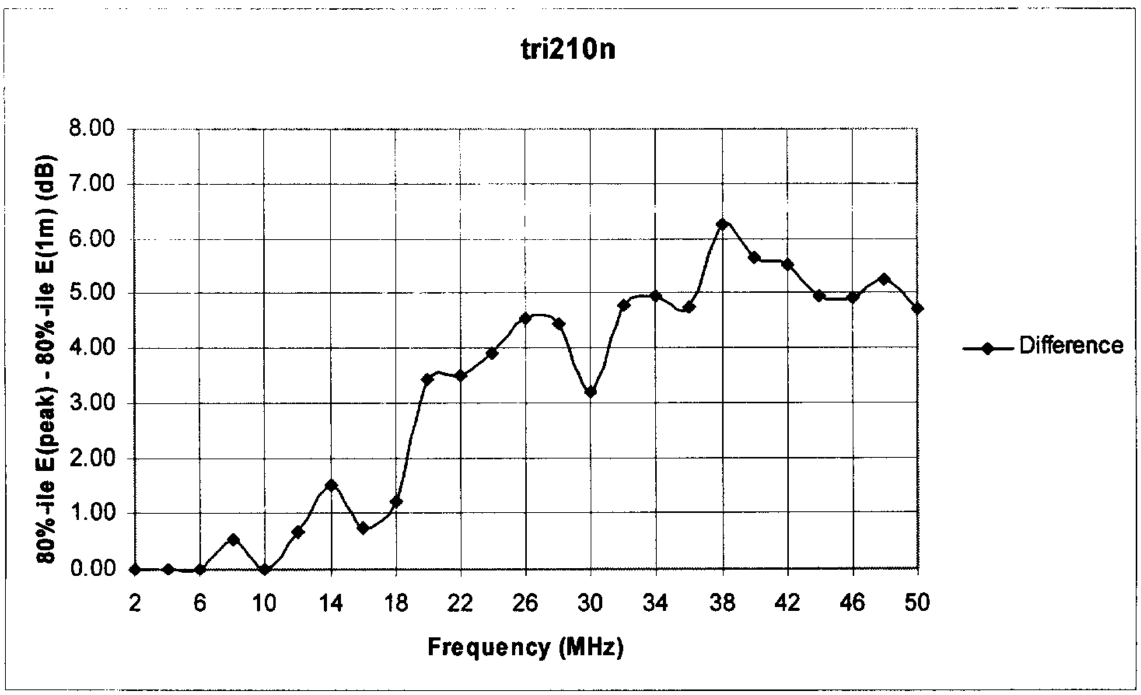

Figure 2-36: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; tri210n power line topology

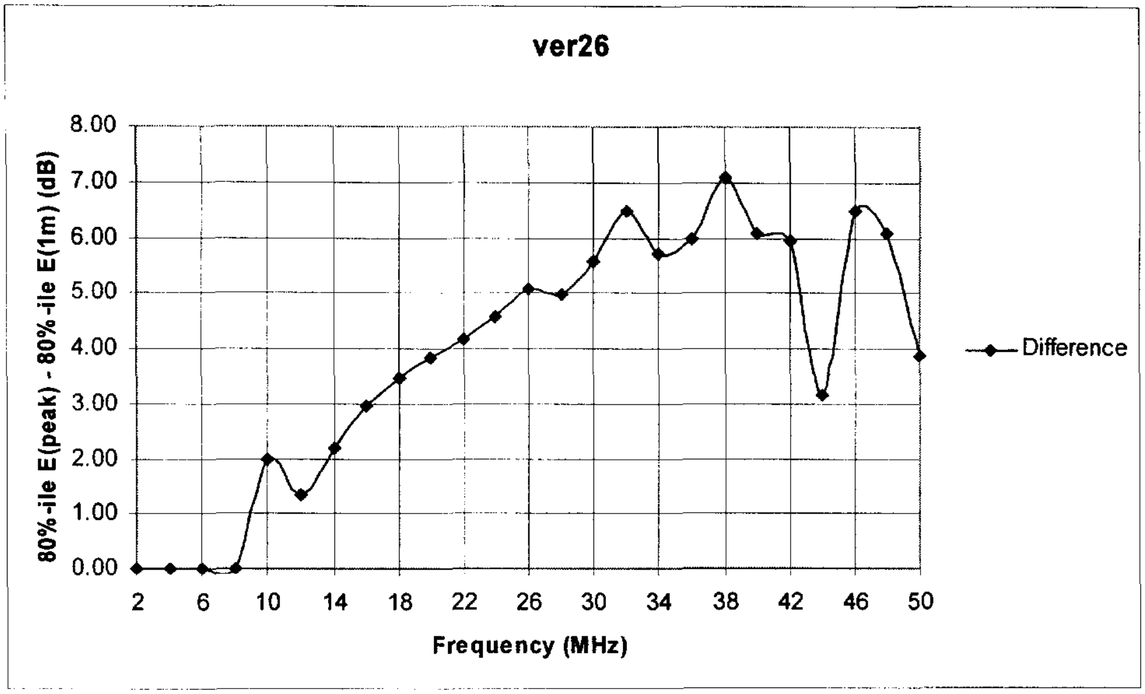

Figure 2-37: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver26 power line topology

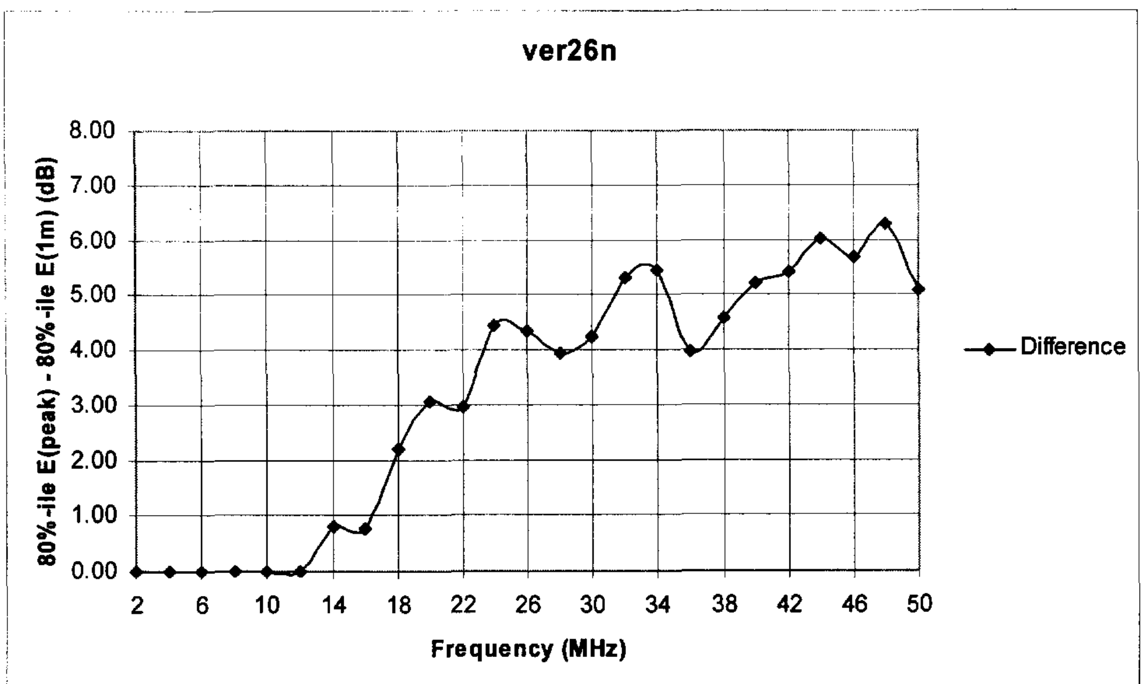

Figure 2-38: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver26n power line topology

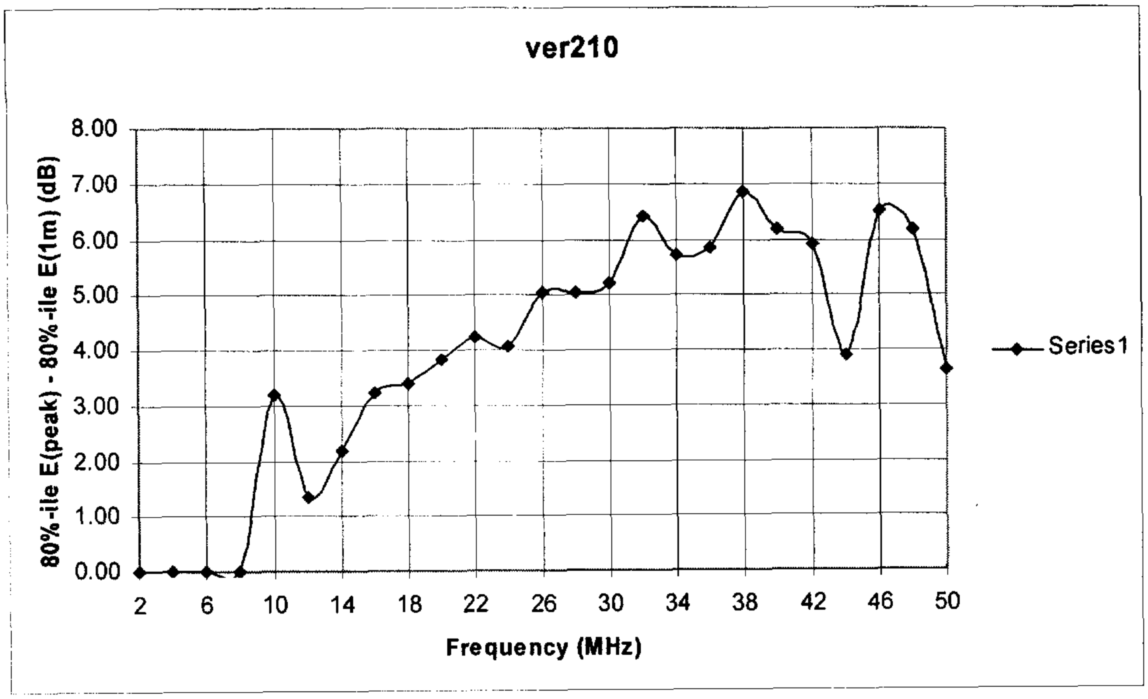

Figure 2-39: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver210 power line topology

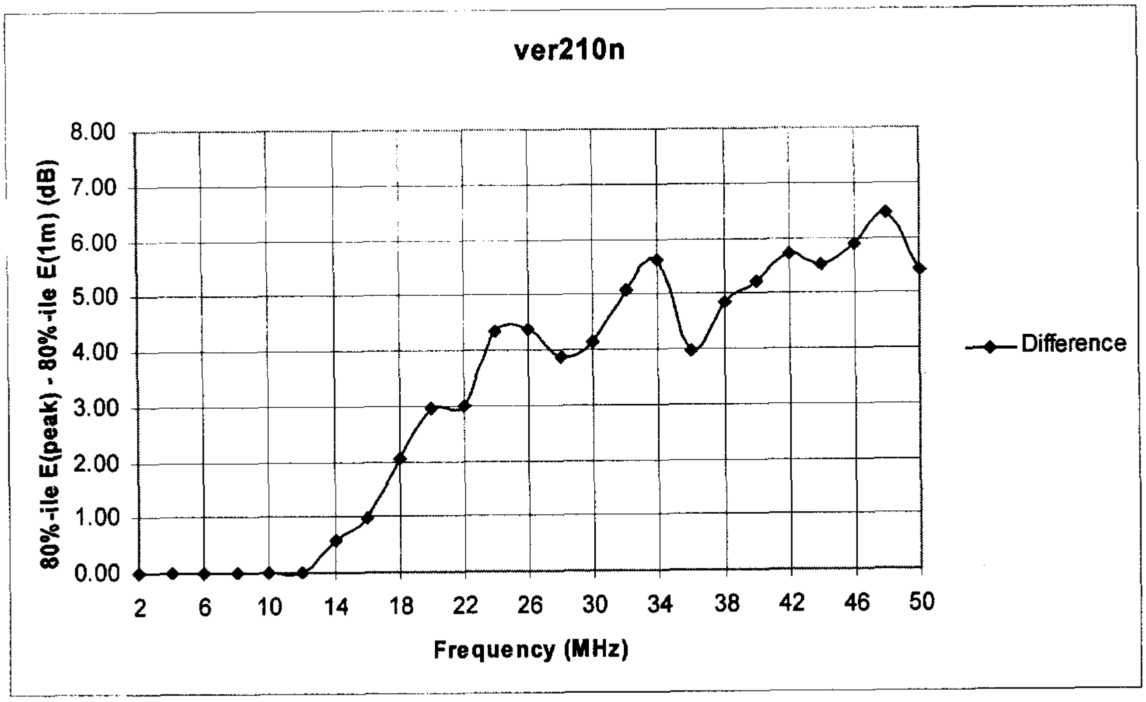

Figure 2-40: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver210n power line topology

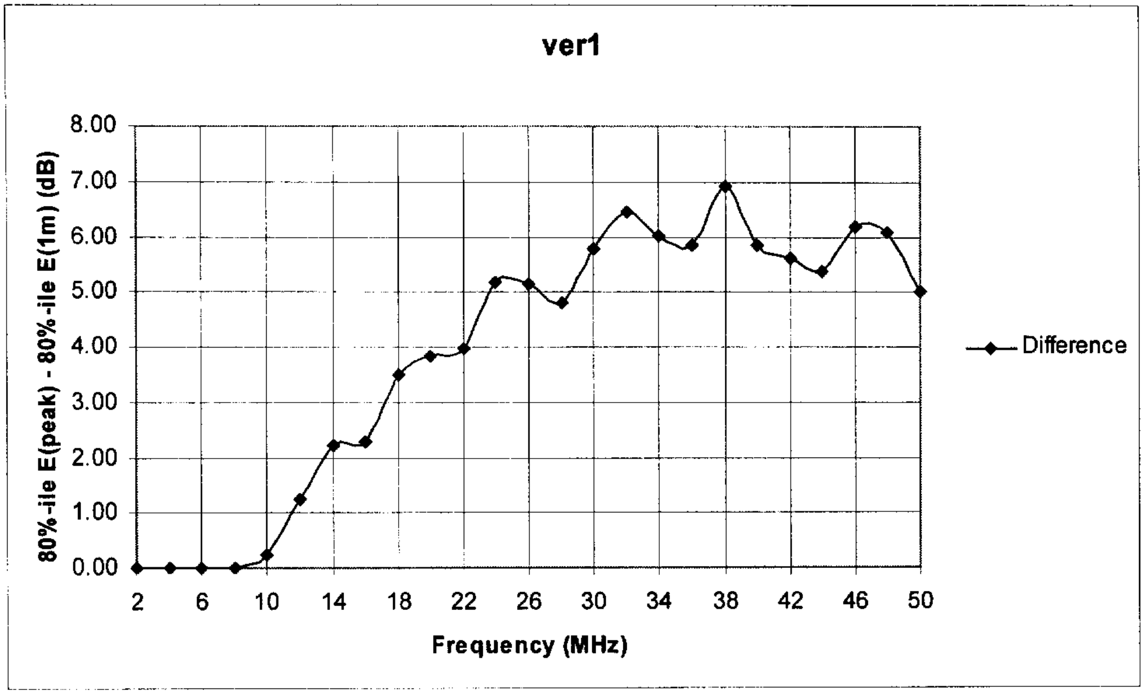

Figure 2-41: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver1 power line topology

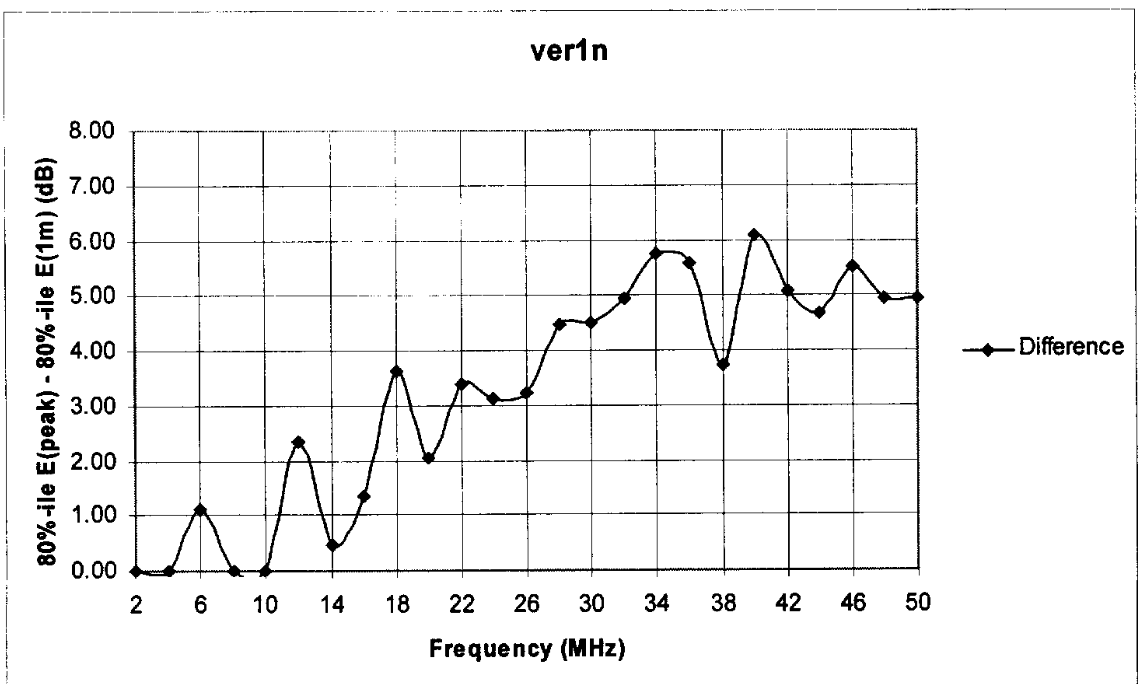

Figure 2-42: Difference between peak field strength at any height and the peak field strength at 1 meter, based on 80th percentile values; ver1n power line topology

SECTION 3
MEASUREMENT DISTANCE ALONG POWER LINE AWAY FROM BPL DEVICES

3.1 INTRODUCTION

As noted in NTIA's Phase 1 report, compliance measurement testing commissioned by BPL equipment vendors and service providers has generally focused on radiated emissions measured on radials from the BPL device under test. However, current FCC guidelines also state that the Part 15 devices and all attached wiring should be considered when measuring radiated emissions.[7] In the Commission's BPL NPRM, the proposed measurement guidelines specify the measurement locations along the power line away from a BPL device.[8] In this section, NTIA evaluates the location along the length of the power line where the peak field strength occurs and the likelihood of finding the peak level at the prescribed locations.

3.2 METHODOLOGY

Field strength predictions from the power line models described in Section 2 were evaluated for the location of peak field strength along the length of the power line. The data correspond to the location 10 meters from the power line where the field strength was at its peak at a height of 1 meter and the location where the field strength was at its overall peak.

3.3 RESULTS

Figures 3-1 through 3-18 show the location where field strength is at its peak level along the power line for a variety of simulated power line configurations and over the frequency range of 2 to 50 MHz. Distances are expressed in terms of wavelengths away from the BPL device. The locations along the power line (10 meters from the power line) where the overall peak and the peak at a measurement height of 1 meter occur are displayed in each figure.

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[7] *See* 47 C.F.R. §15.31(g)-(k).

[8] *See* BPL NPRM, Appendix C at ¶2.b.2 – "Testing shall be performed at distances of 0, ¼, ½, ¾, and 1 wavelength down the line from the BPL injection point on the power line. Wavelength spacing is based on the mid-band frequency…"

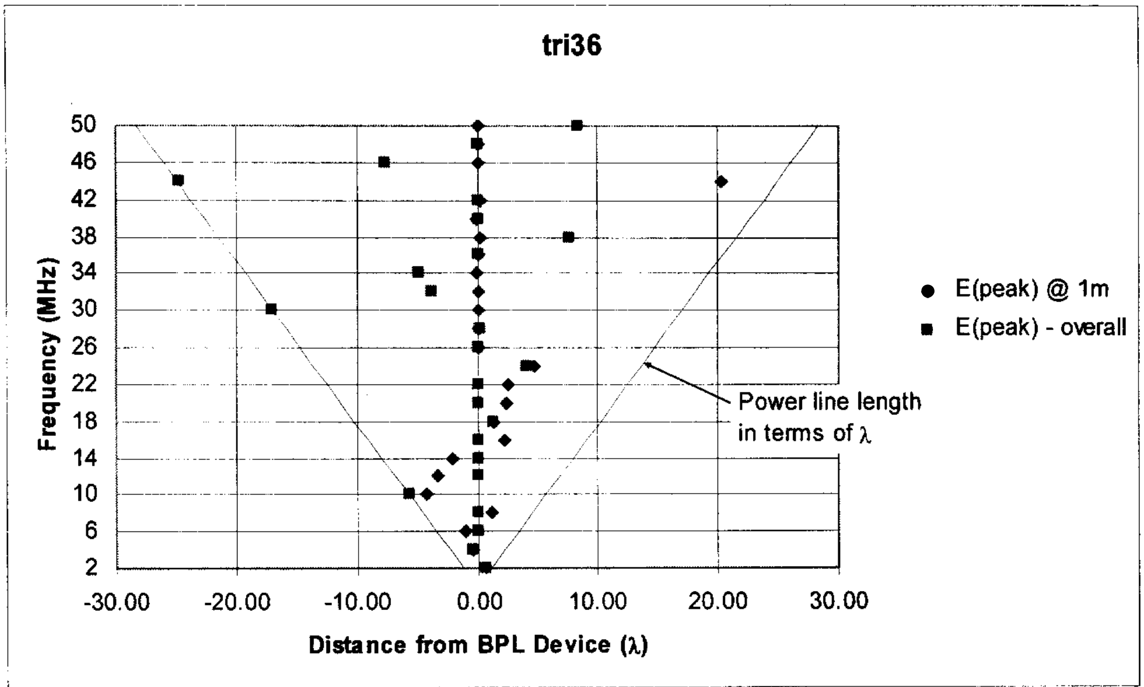

Figure 3-1: Location of peak field strength along the power line – tri36 topology

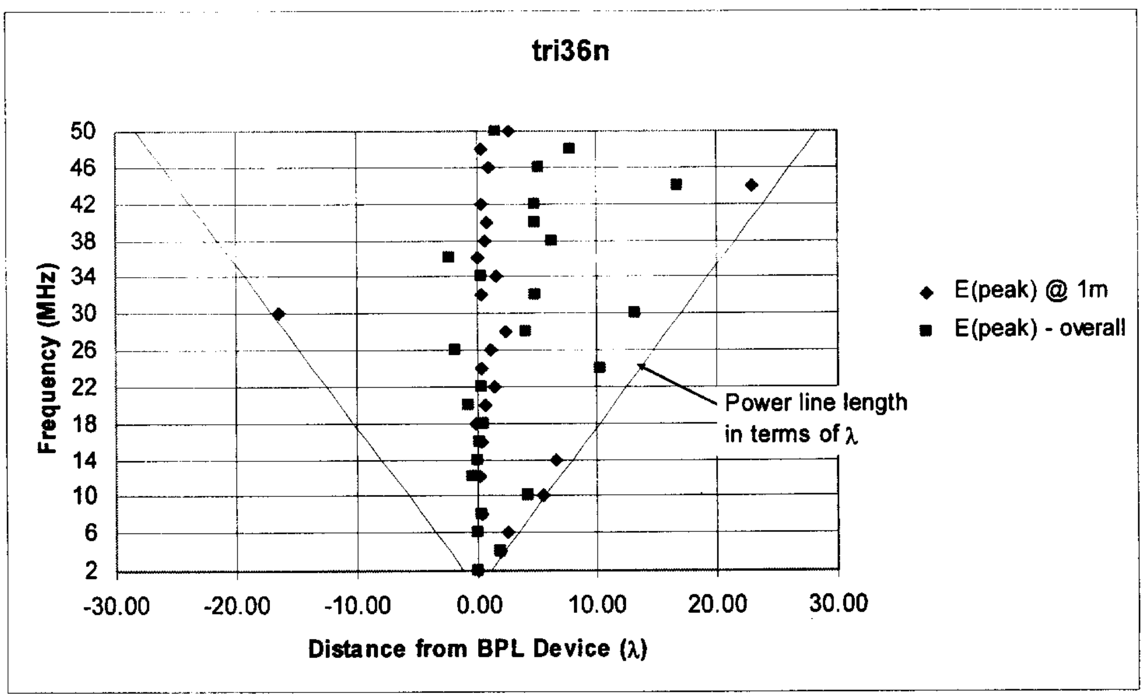

Figure 3 -2: Location of peak field strength along the power line – tri36n topology

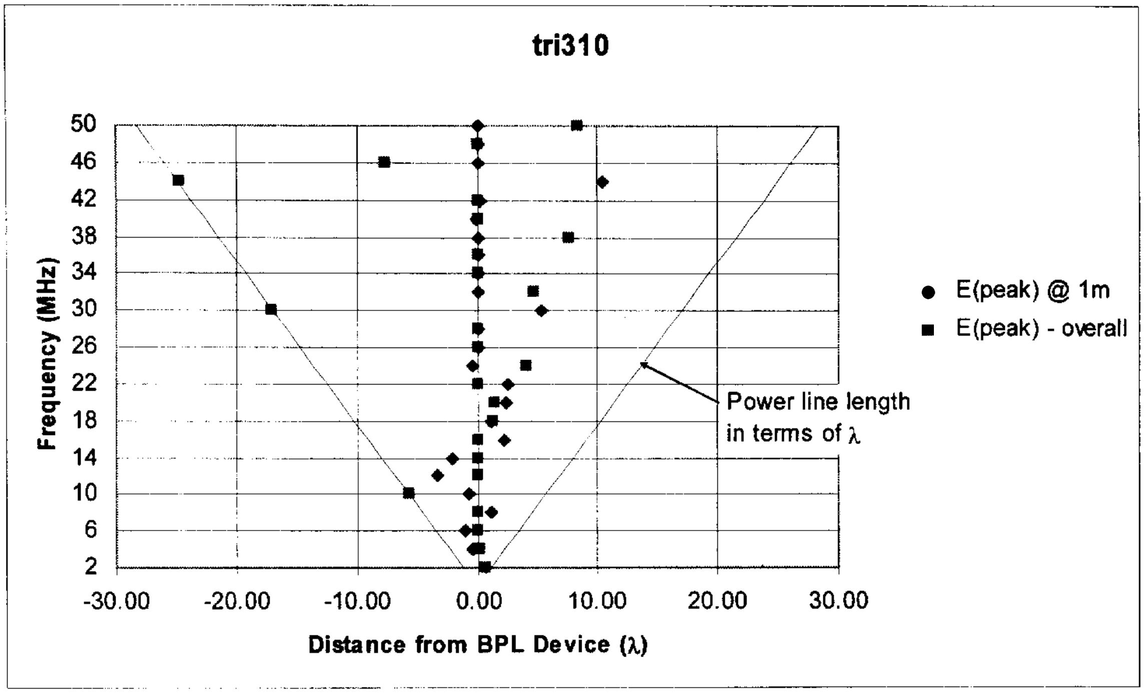

Figure 3-3: Location of peak field strength along the power line – tr310 topology

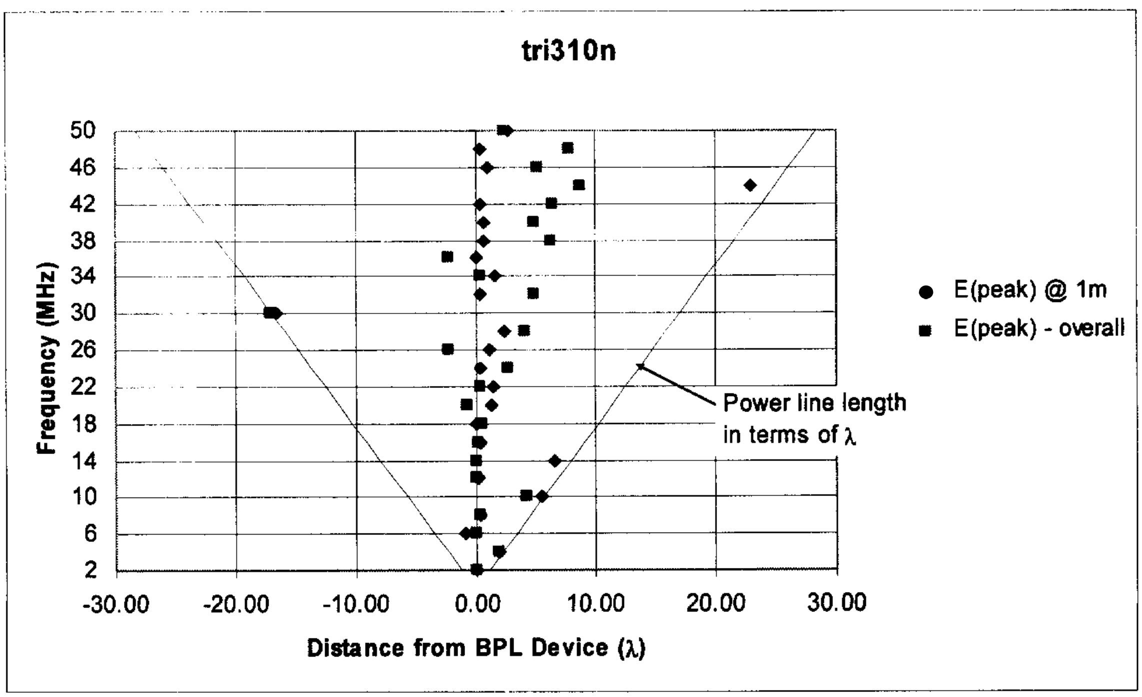

Figure 3-4: Location of peak field strength along the power line – tri310n topology

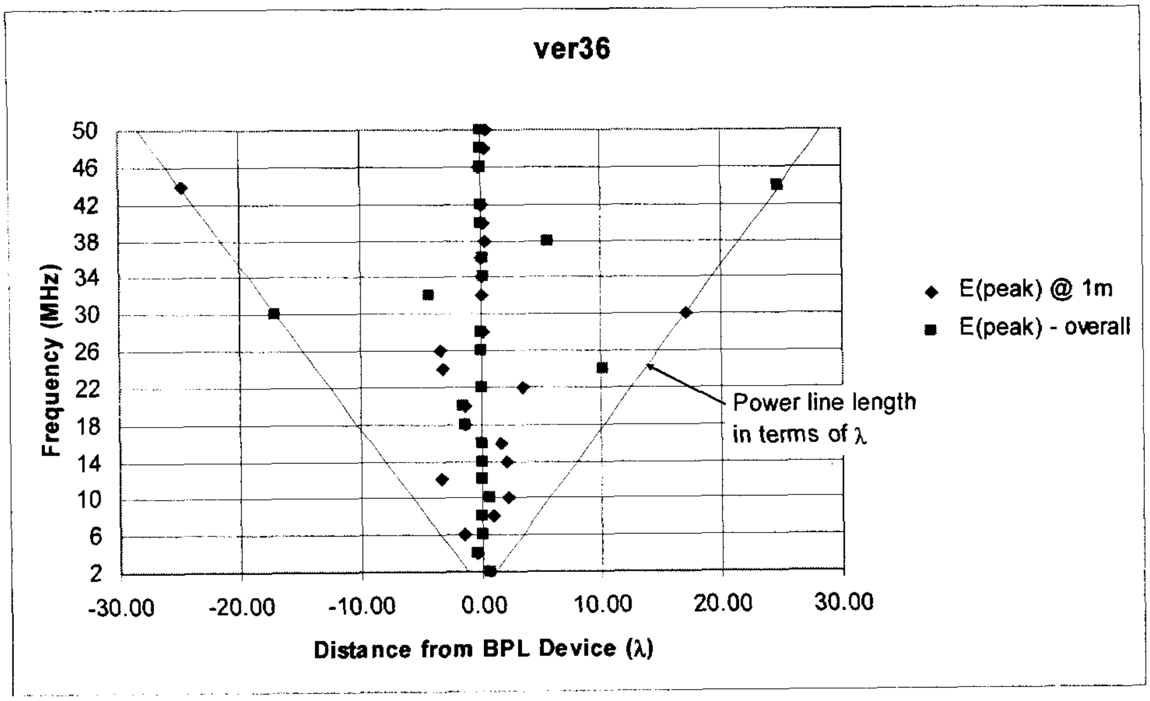

Figure 3-5: Location of peak field strength along the power line – ver36 topology

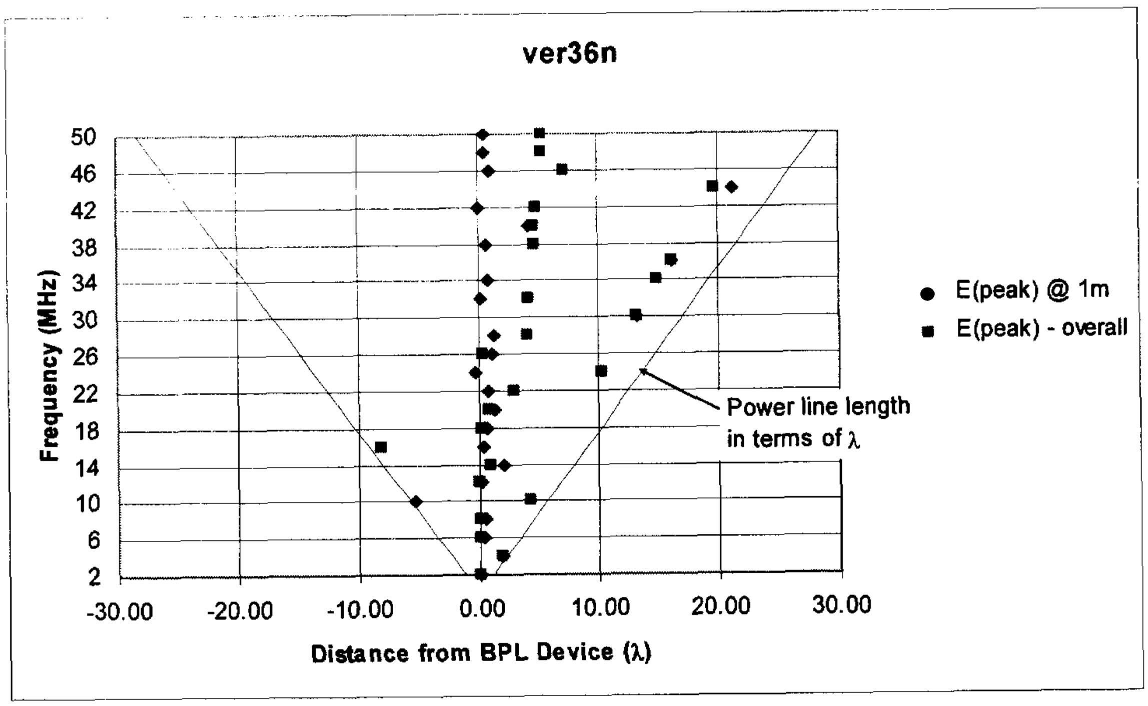

Figure 3-6: Location of peak field strength along the power line – ver36n topology

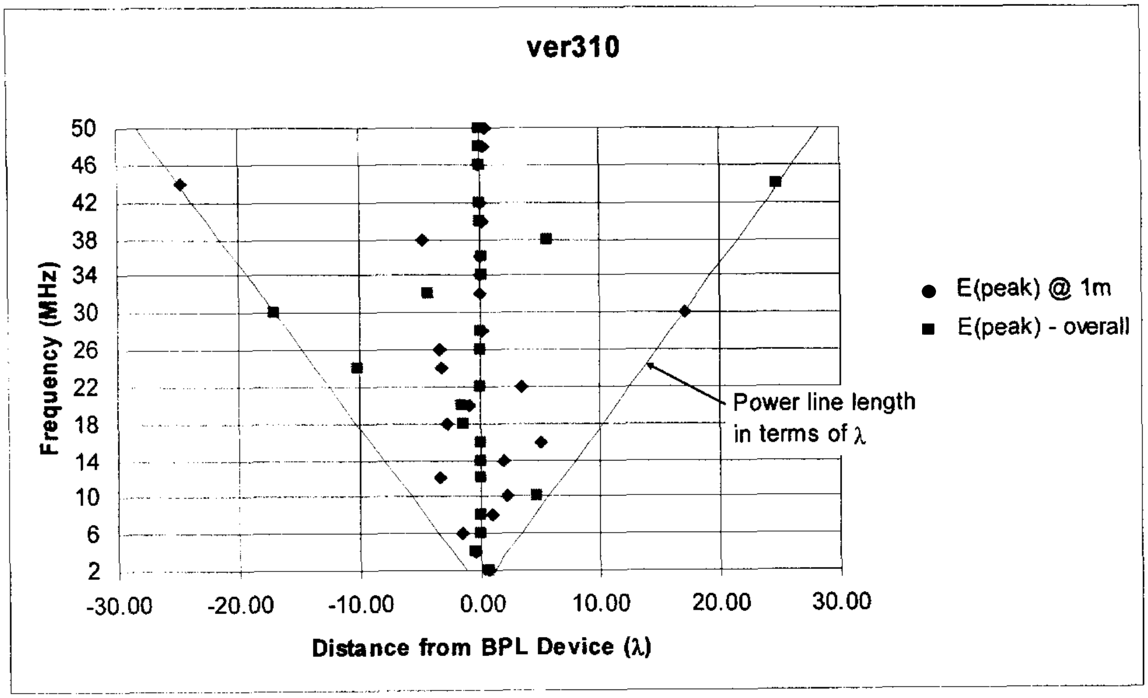

Figure 3-7: Location of peak field strength along the power line – ver310 topology

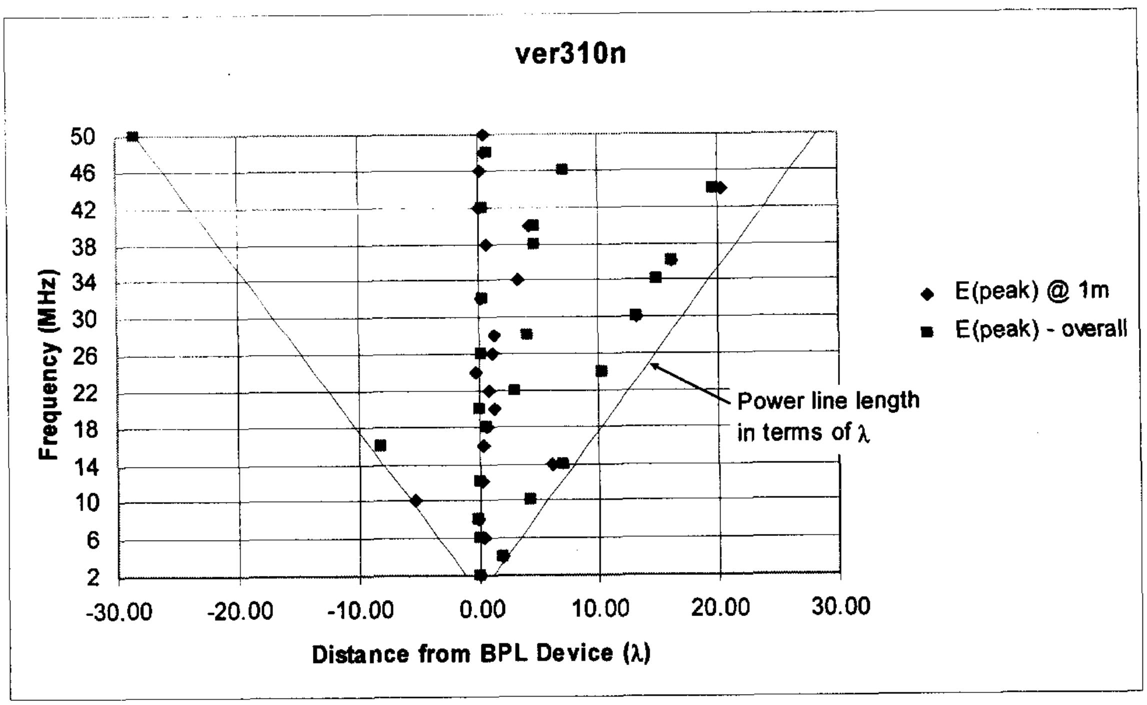

Figure 3-8: Location of peak field strength along the power line – ver310n topology

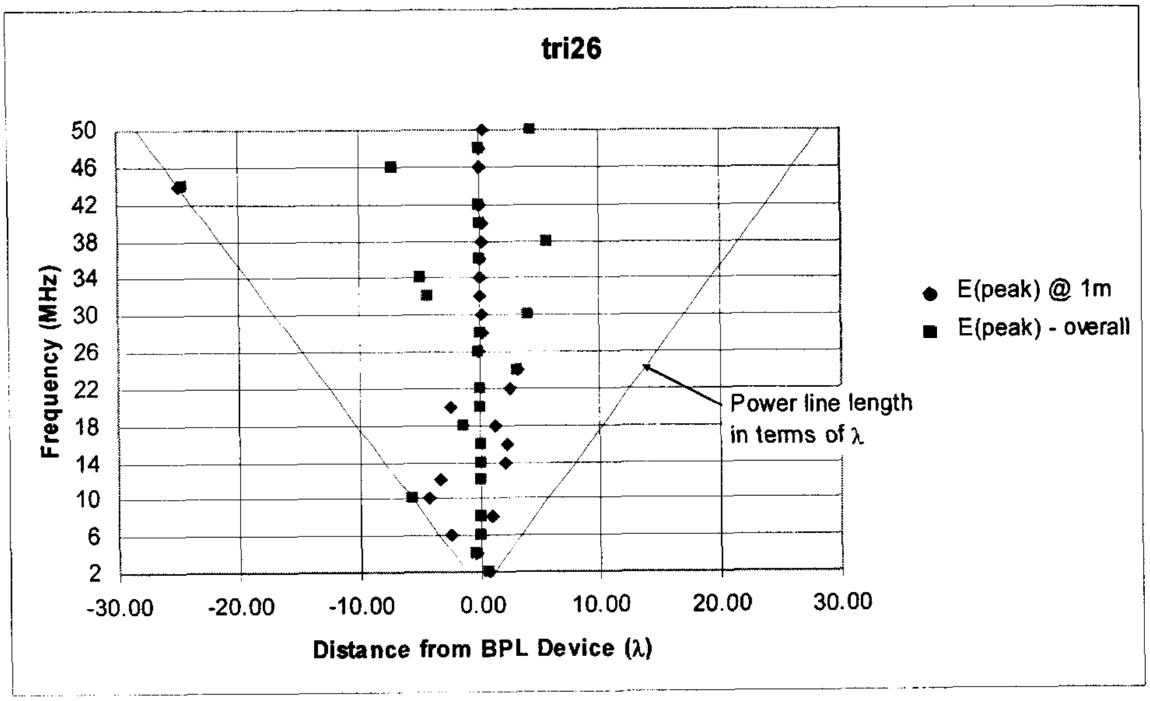

Figure 3-9: Location of peak field strength along the power line – tri26 topology

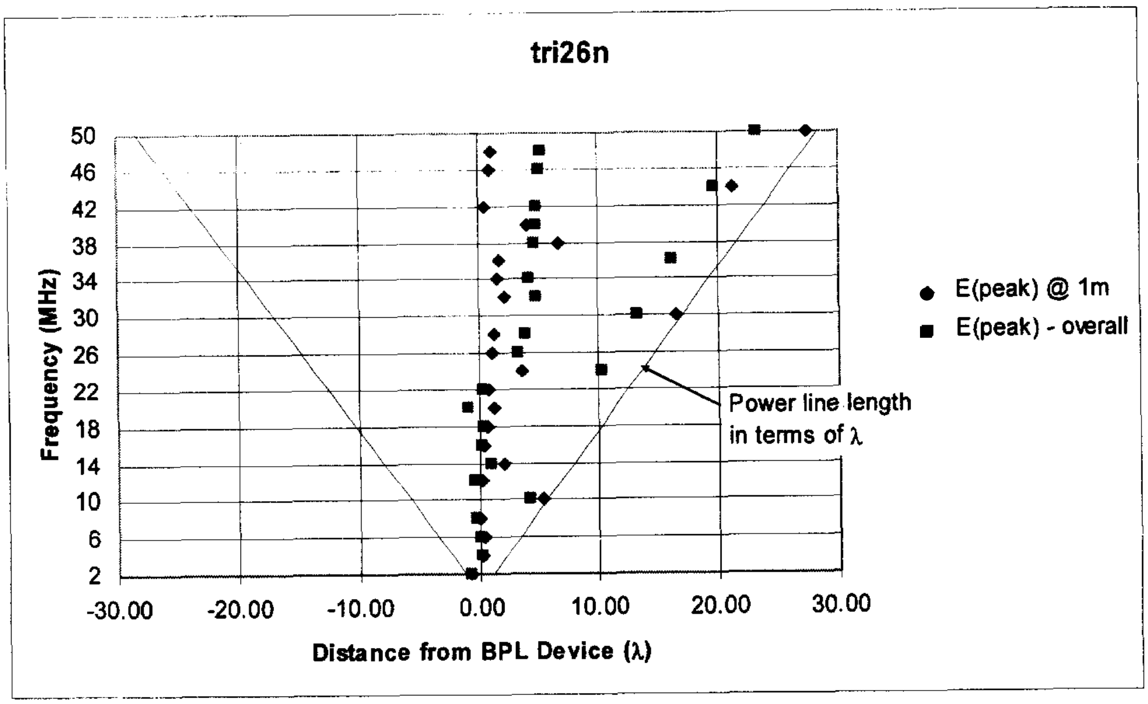

Figure 3-10: Location of peak field strength along the power line – tri26n topology

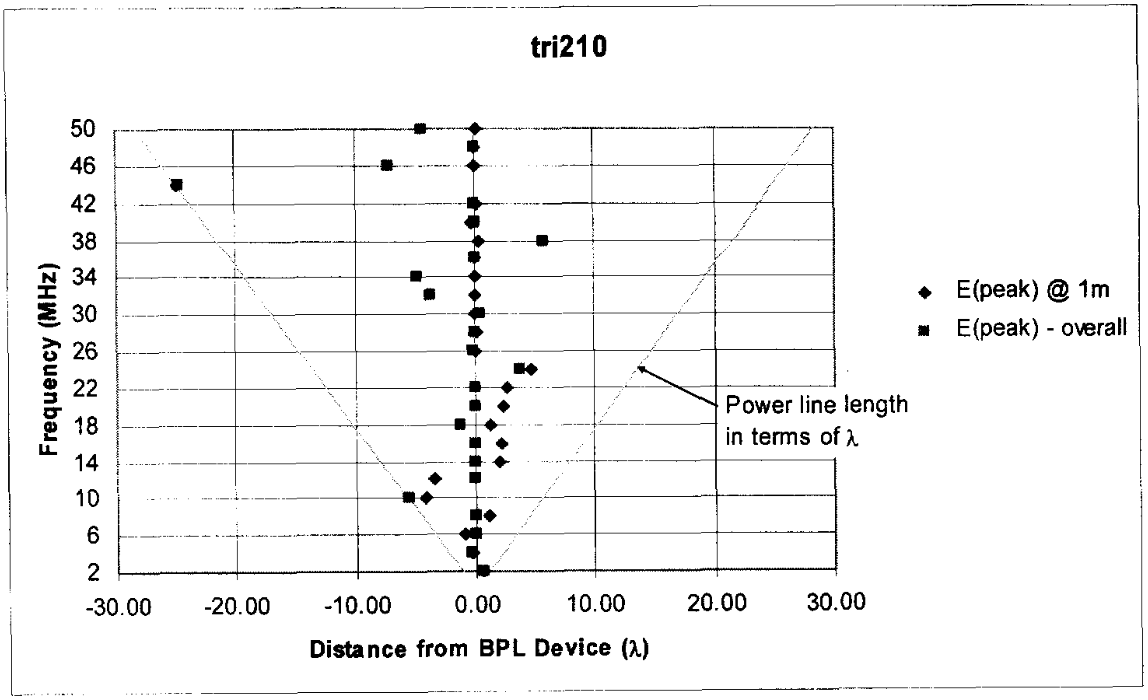

Figure 3-11: Location of peak field strength along the power line – tri210 topology

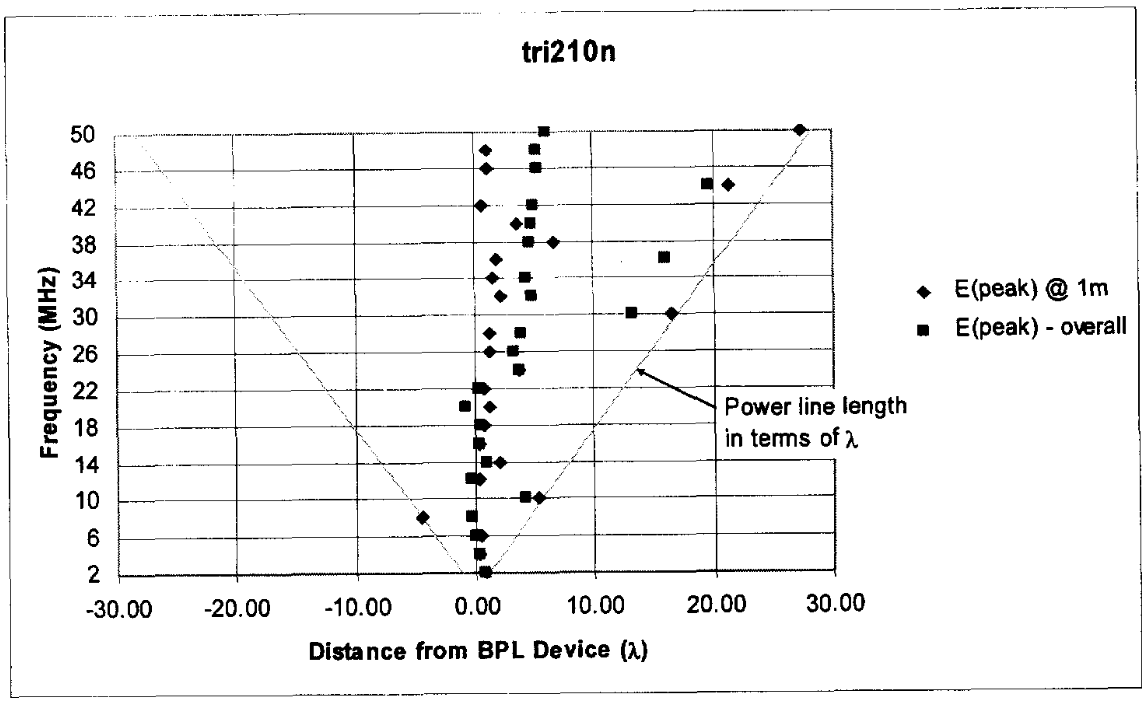

Figure 3-12: Location of peak field strength along the power line – tri210n topology

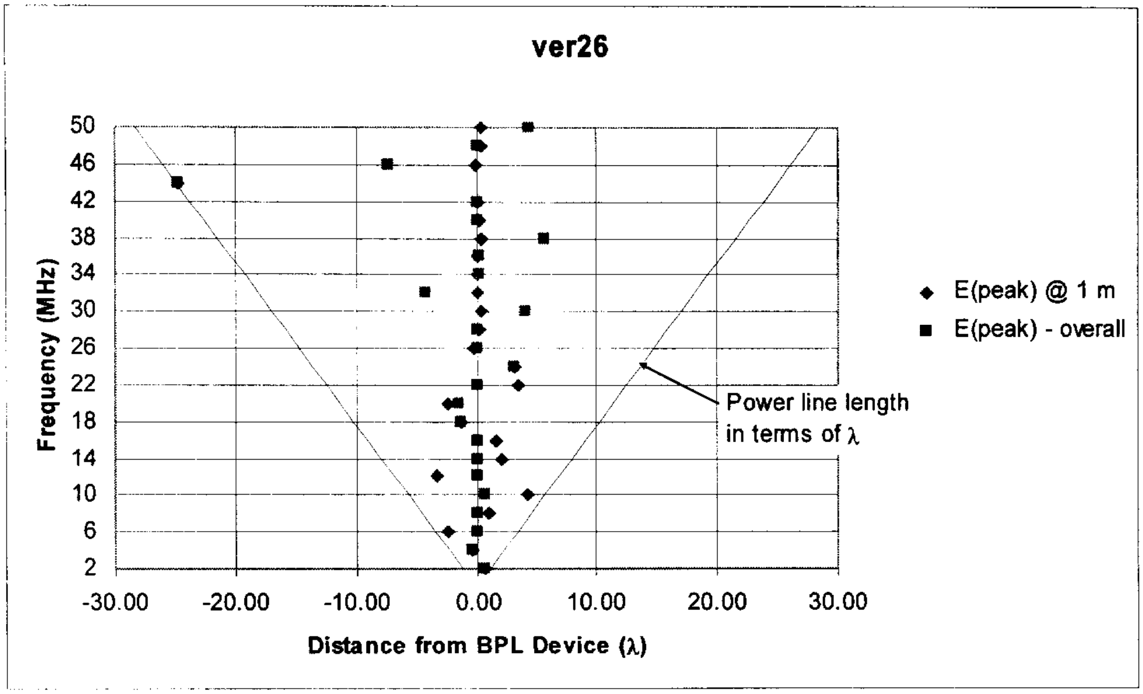

Figure 3-13: Location of peak field strength along the power line – ver26 topology

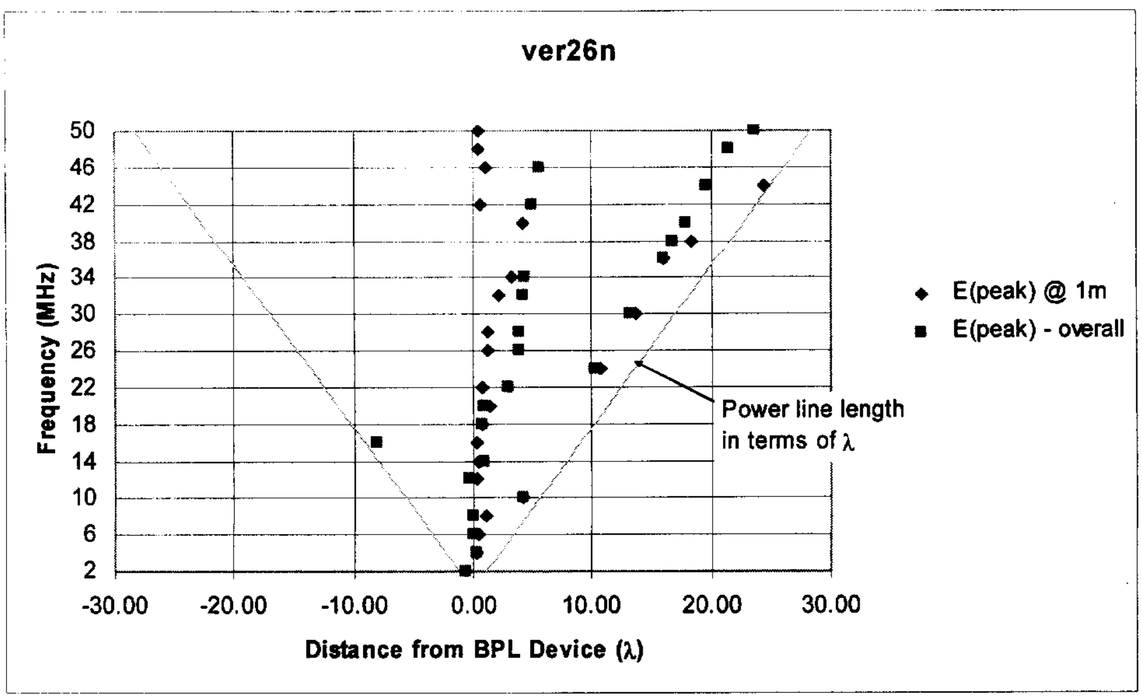

Figure 3-14: Location of peak field strength along the power line – ver26n topology

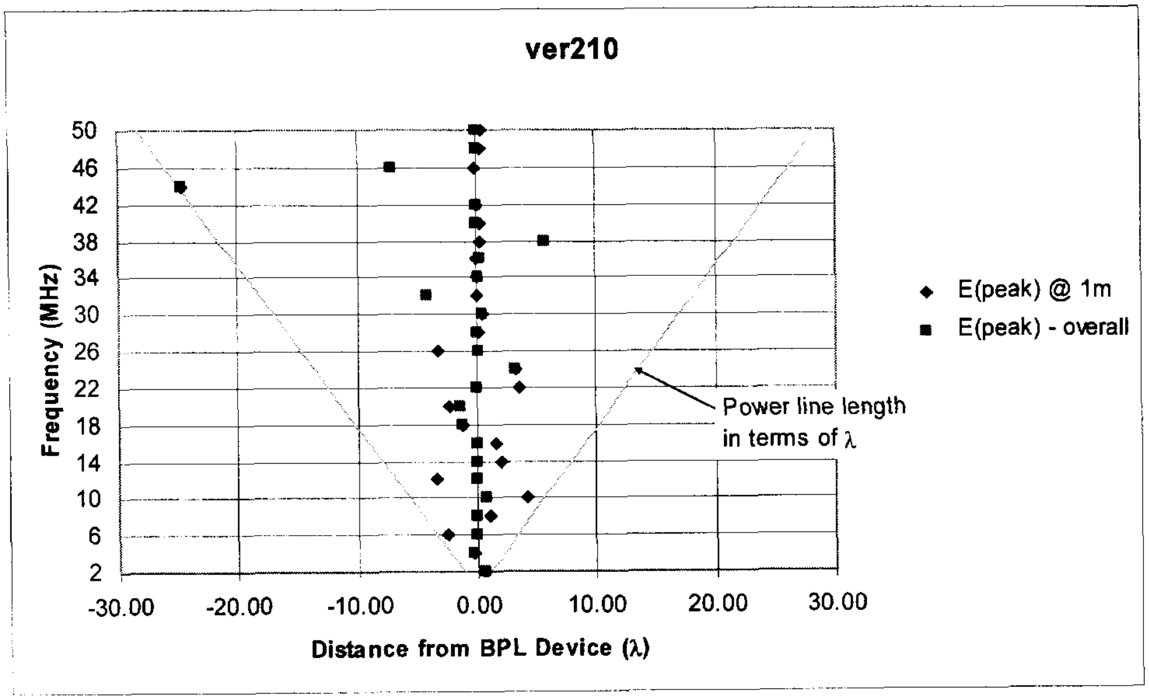

Figure 3-15: Location of peak field strength along the power line – ver210 topology

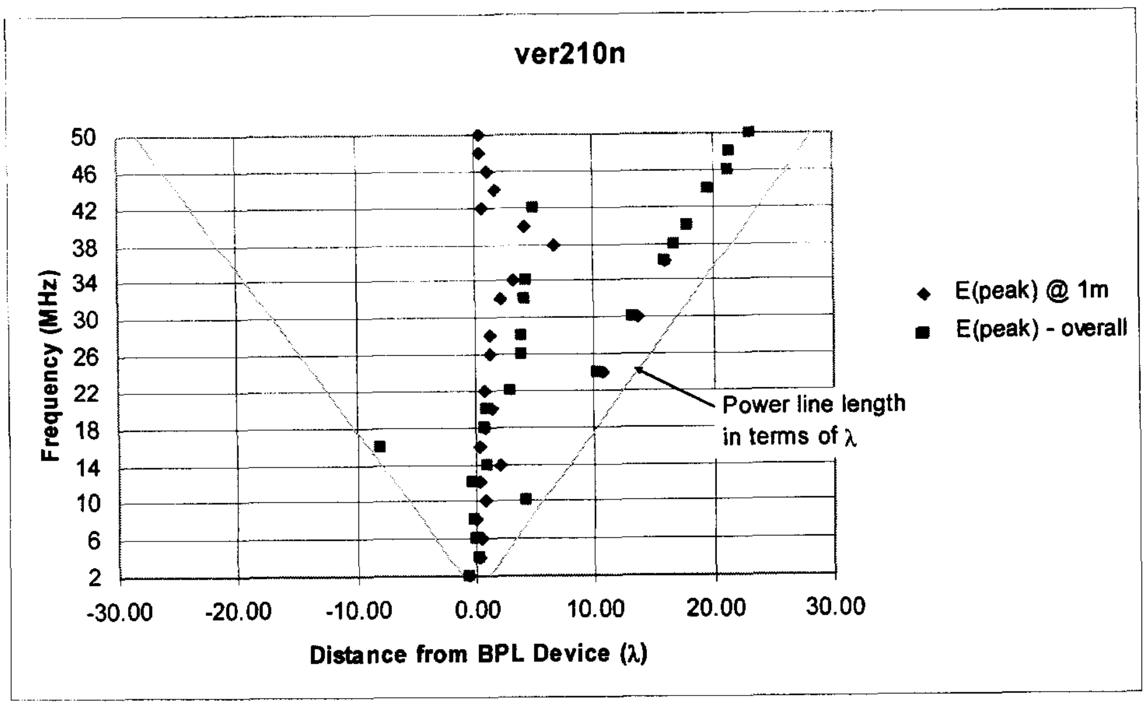

Figure 3-16: Location of peak field strength along the power line – ver210n topology

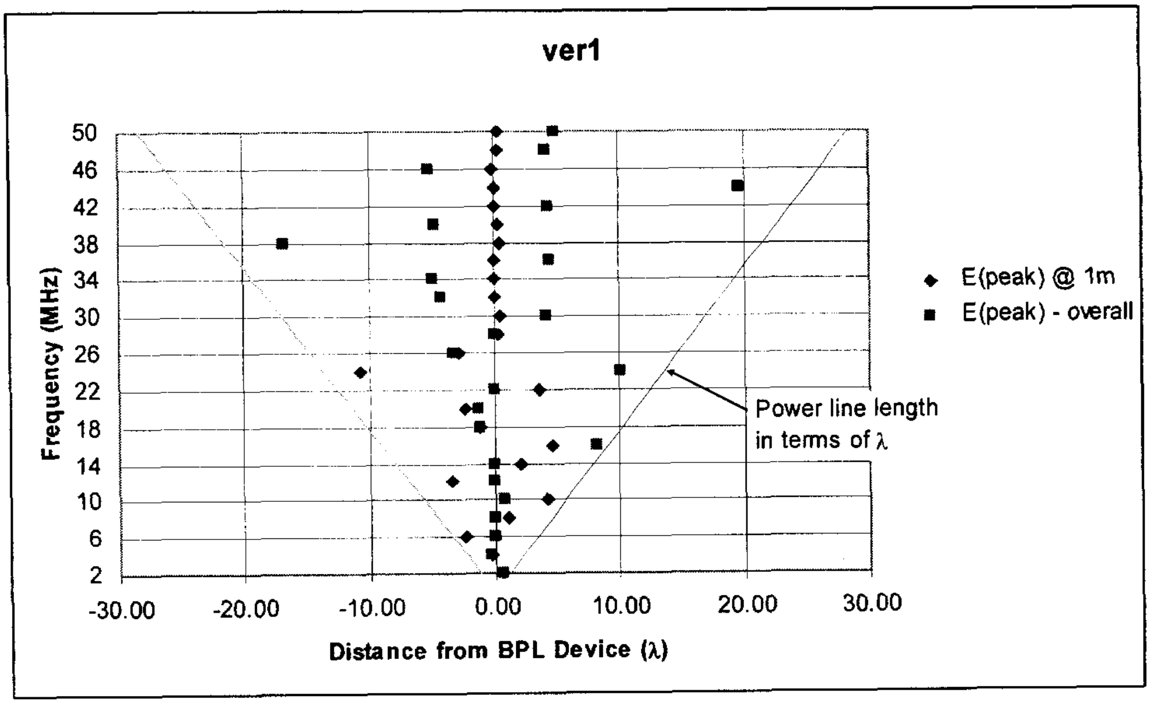

Figure 3-17: Location of peak field strength along the power line - ver1 topology

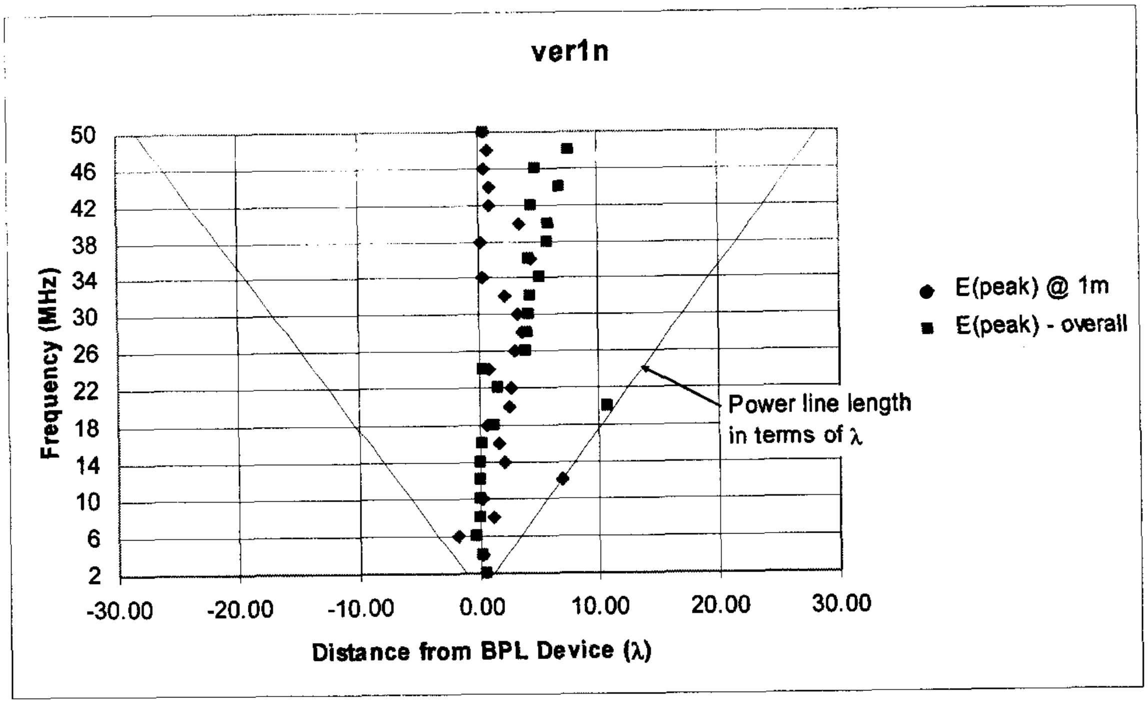

Figure 3-18: Location of peak field strength along the power line – ver1n topology

3.4 CONCLUSION

From the figures in Section 3.3, the locations all along the length of the power line where the field strength is at its peak, both at heights of 1 meter and overall, vary widely. For any given power line configuration, at some frequencies the peak occurs adjacent to or near the BPL device, while at other frequencies the peak occurs at substantial distances from the BPL device at an impedance discontinuity. There are also many frequencies where the field strength peaks at various distances along the power line. The variability of these results from power line to power line is due to different degrees of asymmetry in the power line structures and the fact that the electric field was calculated at a fixed horizontal distance (10 meters) from the power lines. The signal source was positioned on an outer conductor at a small positive (x-axis) offset from the center of the power line structure. The results are more asymmetric when a neutral wire is added to the power line structure, due to introduction of additional asymmetry. These results argue against use of the measurement locations proposed in the Commission's BPL NPRM. NTIA recommends that field strength measurements be performed at a 10 meter horizontal distance from an Access BPL power line, at points all along key segments of the power line where the maximum field strength from BPL emissions is expected to occur. In its ongoing Phase 2 study, NTIA will continue to investigate emissions along the power lines and recommend criteria for choosing representative segments of power line to measure.

SECTION 4
IONOSPHERIC PROPAGATION OF BPL SIGNALS

4.1 INTRODUCTION

Sky wave ionospheric propagation may occur above the power line horizon for frequencies between 1.7 MHz and 30 MHz, as discussed in NTIA's Phase 1 report. Sky wave propagation may be represented by rays which are refracted and reflected from the ionosphere and is responsible for signal transmission to distances ranging from hundreds to thousands of kilometers, depending on elevation angle of the radiated field, frequency and parameters of the ionosphere that exhibit temporal and spatial variability. The ionosphere, which ranges from about 60 to 600 km in height, acts as a low-conductivity dielectric.[9] In general, sky waves are reliable for radiocommunications up to about 30 MHz, above which this mode of propagation is sporadic.

Sky waves suffer large losses mainly due to ionospheric absorption and polarization coupling losses. In a widespread deployment of BPL systems, there may be aggregation of co-frequency BPL emissions toward the ionosphere. The modeling results in the Phase I report suggest that there is relatively strong radiation in directions above the power line horizon (*i.e.*, higher than radiation toward directions below the power lines), and so, aggregation of BPL signals at locations above power lines may be more significant than at lower heights where BPL signal propagation is less efficient.

4.2 ANALYTICAL MODELING OF SKY WAVE PROPAGATION

The goal of this preliminary analysis of aggregation and ionospheric propagation from widespread deployment of BPL systems was to gauge whether it could lead to interference in the near-term (next few years). Accordingly, the analysis has a worst-case orientation.

To make predictions regarding the large-scale effects of a widespread BPL deployment, NTIA employed the VOACAP HF propagation software developed at its Institute of Telecommunication Sciences (ITS).[10] NTIA modeled propagation under a range of times, months and frequencies to determine potentially worst-case I/N conditions. In this process, NTIA used VOACAP's "point-to-point" mode to find potential time, seasonal and frequency combinations that produced the highest I/N levels between several points around the nation. VOACAP's "area" mode was then used to further refine these predictions by determining the geographic coverage of relatively high I/N levels due to single transmitters placed around the nation as propagation factors were varied.

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[9] *See e.g.*, Propagation of Radio Waves, Edited by M. P.M Hall, L. W. Barclay and M. T. Hewitt, IEE, London, 1996.

[10] VOACAP is available from the NTIA Institute for Telecommunication Sciences, URL: http://elbert.its.bldrdoc.gov/hf.html.

Using these values, NTIA then ran VOACAP in its area mode to obtain interfering signal and noise power values in a fixed 31×31-point grid of receiving points covering the United States and centered on Kansas City, Missouri. For this step, NTIA placed BPL devices in the geographic center of each county in the United States (including Alaska and Hawaii). Each of the BPL transmitters (corresponding to a county) was assigned a radiated power that would produce field strength at the level of the Part 15 limit as measured using existing procedures. The total radiated power of each BPL device is shown in Table 4-1. These power levels were scaled by the number of active BPL devices expected to serve the urban households in each county.[11]

Table 4-1: BPL Total Radiated Power

Frequency (MHz)	Power (dBW/Hz)
4	-104.26
15	-101.79
25	-99.35
40	-123.15

Several other factors were taken into consideration when predicting the interference-to-noise ratio. BPL devices will not all operate at the Part 15 limit; therefore, the average field strength was assumed to be 4 dB below the Part 15 limit. The analysis was based on RMS values; therefore an adjustment was made to convert the quasi-peak BPL signal level to an RMS level. Finally, since the devices in the system do not all operate at the same frequency, an allowance of 6 dB was given (*i.e.*, 1 in 4 BPL injectors are assumed to be co-frequency). These adjustment factors are listed in Table 4-2.

Table 4-2: Adjustment Factors

Factor	Adjustment (dB)
Devices operating at levels below Part 15 limits	4
Quasi-Peak to RMS S/N difference	3
Co-frequency distribution factor	6
Total	13

All simulated BPL transmitters were given an average antenna pattern based upon the NTIA NEC far-field simulations of a complex power line model (Figure 2-2). This model was based upon a real Medium Voltage (MV) power line configuration at a test BPL deployment area. The NEC-derived far-field patterns were arithmetically averaged over azimuth, assuming a random distribution of power line orientations, which resulted in gain patterns with variation in elevation only.

The VOACAP program's variable inputs for this analysis are listed in Table 4-3.

[11] For this preliminary analysis, NTIA assumed that a BPL injector has the data handling capacity to support an average of 30 customers, and 1 of 4 urban households is a BPL customer. In other words, one BPL injector was assumed per 120 urban households.

Table 4-3: VOACAP Input Parameters

Variable	Value	Comment
Smoothed Sunspot Number (SSN)	150	Yields efficient propagation
Month	December	Yields good propagation and low noise
Time (UTC)	18:00	
Frequency (MHz)	23	
Manmade Noise at 3 MHz (dBW/Hz)	-164	Relatively low value
BPL Total Radiated Power (dBW/Hz)	-100	Maximum coupled BPL power for compliance with limit*

4.3 RESULTS

Aggregated output for a simulated nationwide deployment of over 700,000 Access BPL devices is depicted in Figure 4-1. The calculated hourly median I/N (VOACAP refers to it as S/N) level under these circumstances are greater than –17 dB over the continental United States, with hourly median I/N levels through much of the central United States between -8.4 dB and -11 dB. Thus, the highest expected hourly median increase in ambient noise due to the assumed extensive deployment of BPL devices would be less than 1 dB.

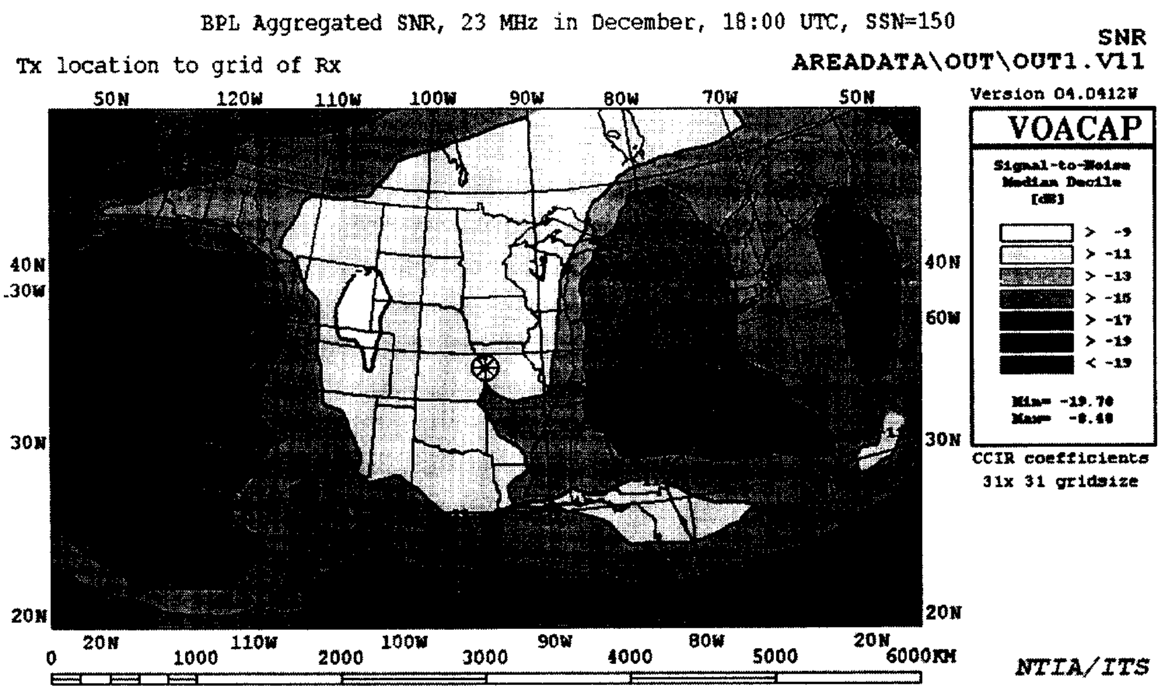

Figure 4-1: Aggregated BPL I/N levels due to ionospheric propagation (Existing Rules, Worst-Case Oriented Analysis)

* The maximum coupled BPL power that yields compliance with field strength limits can vary substantially among different power lines.

4.4 CONCLUSION

NTIA's worst-case oriented analysis of ionospheric propagation and aggregation of emissions from Access BPL systems indicates that interference via this mechanism will not occur in the near term. Considering realistically dispersed deployments of BPL systems, it would take hundreds of thousands of Access BPL devices operating under existing rules to cause a 1 dB increase in median noise. Under NTIA's recommended rule elements, chiefly the 5 dB height correction factor and power control, it would take millions of BPL devices to increase the median noise by 1 dB.

SECTION 5
INTERFERENCE RISK ANALYSES

5.1 INTRODUCTION

In its Phase 1 study, NTIA analyzed the risk of interference to various representative federal radio systems assuming BPL devices are operating at Class B emissions limits above 30 MHz under the current Part 15 rules. The interference risks were evaluated for two interfering signal thresholds: a doubling of receiver noise floor (I+N/N = 3 dB) that would result in interference in a low percentage of cases, and a ten fold increase in receiver noise floor (I+N/N = 10 dB) that would result in interference in a moderate percentage of cases. This section extends the Phase I study interference risk analyses to include operation of BPL devices at current Part 15 limits for Class A digital devices. In addition, the effect of NTIA's recommended 5 dB height correction factor is evaluated for the case of a land-mobile receiver in close proximity to an Access BPL power line.

5.2 BPL OPERATIONS AT CURRENT PART 15 RULES ABOVE 30 MHz

NTIA analyzed four representative federal radio systems assuming operation at Class A emissions limits above 30 MHz.[12] Figures 5-1 through 5-3 show the percent of locations, by distance from the Access BPL power lines, which could experience a noise floor increase of 3 or 10 dB. Both Class A and B results are plotted for land mobile, fixed and maritime stations, respectively.

Figures 5-4 through 5-6 illustrate the noise floor increase that an aeronautical receiver would experience at various altitudes and horizontal distances from the centroid of an area where BPL systems are deployed. As in the NTIA Phase 1 study, this deployment area has a 10 kilometer radius and the assumed density of co-frequency active BPL devices was one per square kilometer. Both Class A and B results are shown for the aeronautical receiver operating at an altitude of 6, 9 and 12 kilometers.

[12] *See* NTIA Phase 1 Study, at §6.

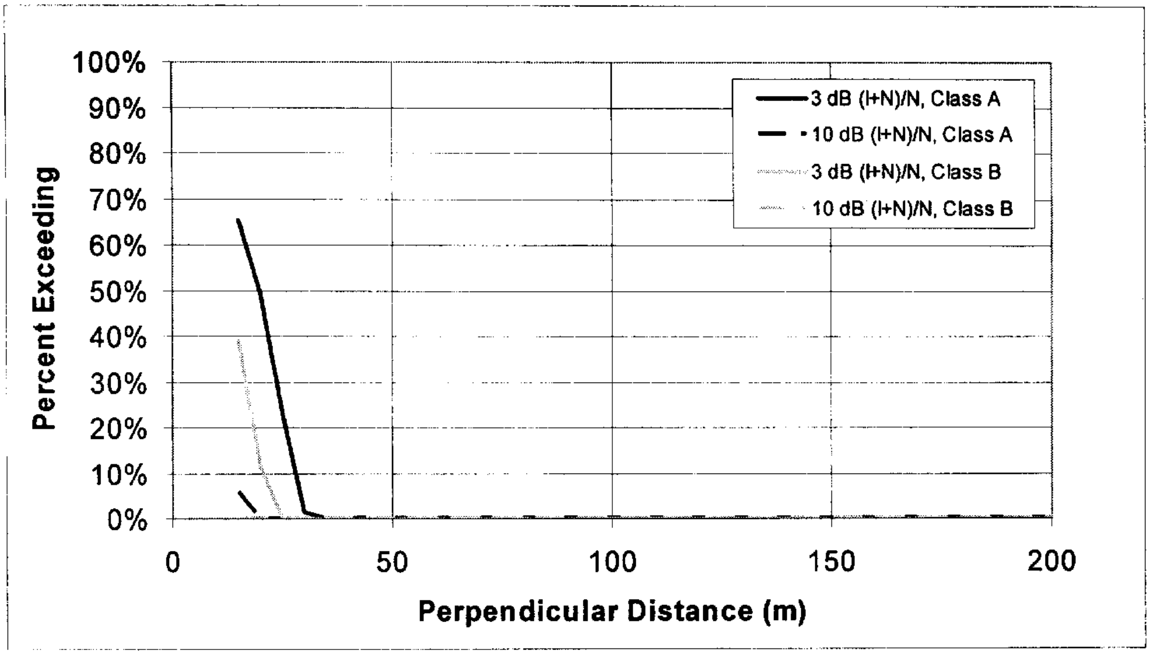

Figure 5-1: Percent of locations, by distance, exceeding the specified (I+N/N) levels at 40 MHz – Land-mobile receiver

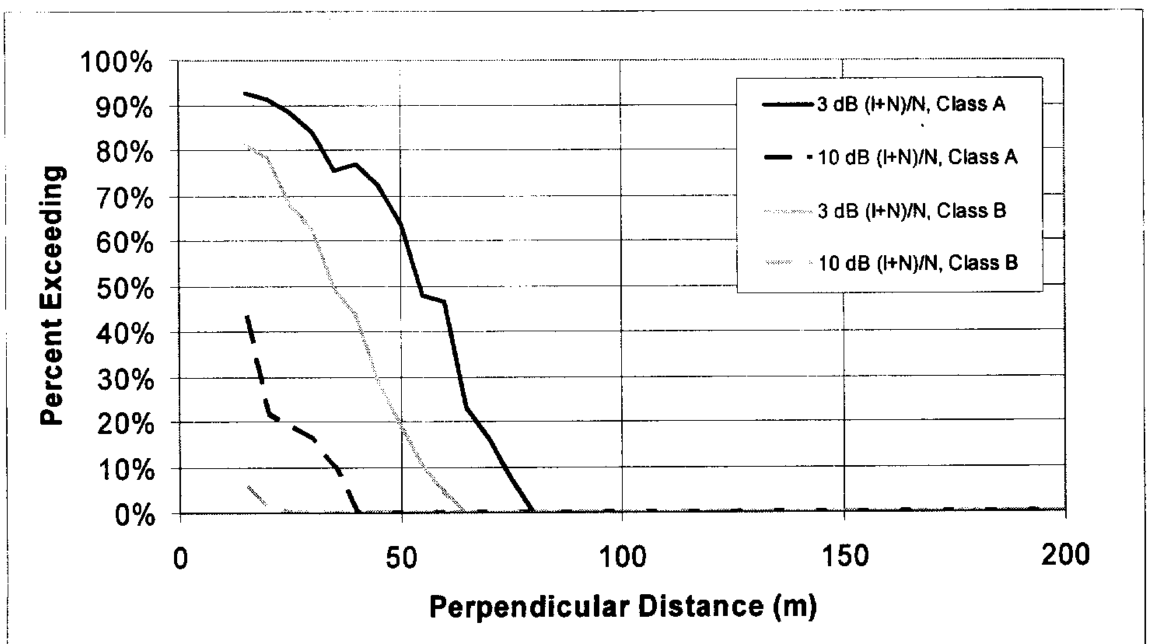

Figure 5-2: Percent of locations, by distance, exceeding the specified (I+N)/N levels at 40 MHz – Fixed receiver

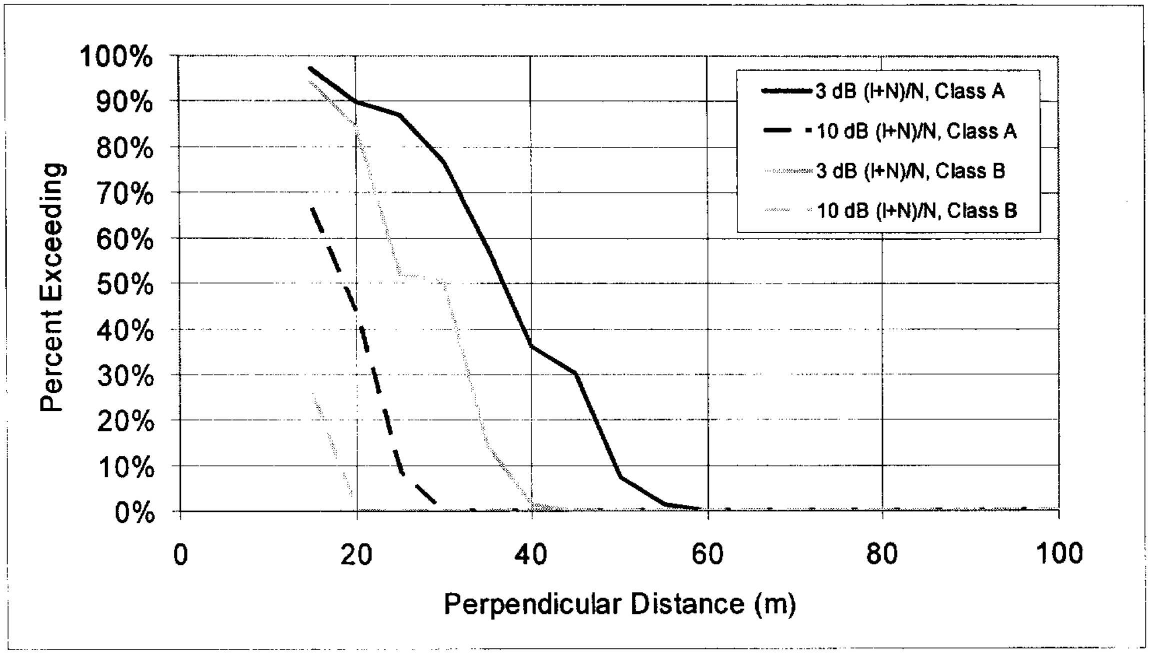

Figure 5-3: Percent of locations, by distance, exceeding the specified (I+N)/N levels at 40 MHz – Maritime receiver

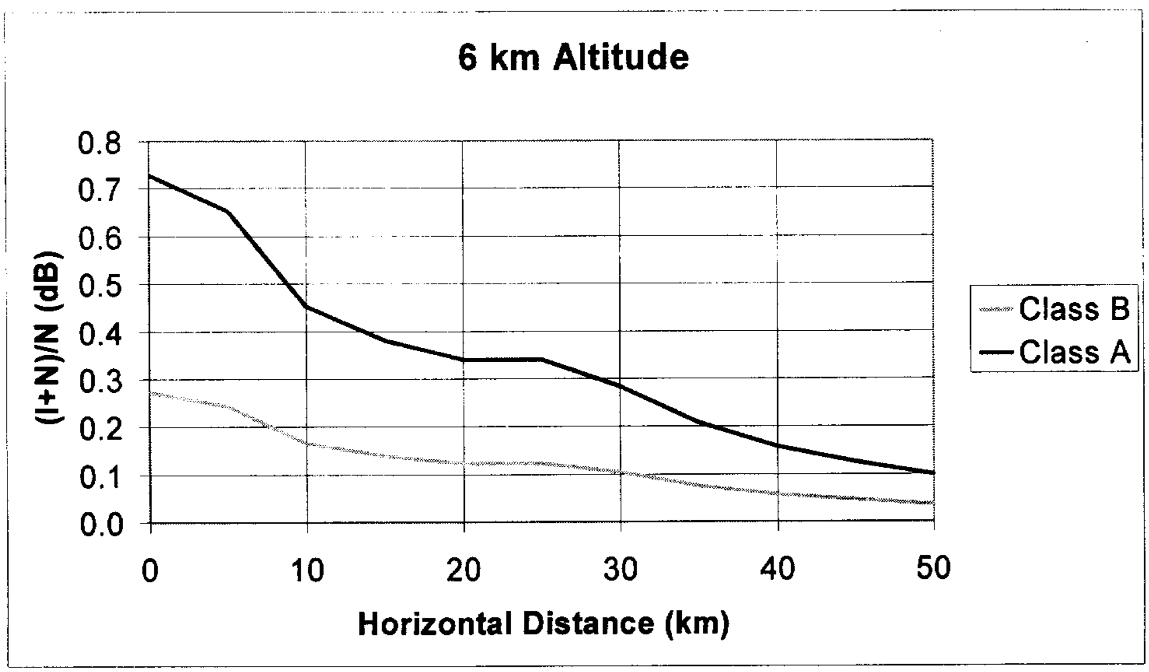

Figure 5-4: Calculated (I+N)/N level for an aeronautical receiver at the specified distance and 6 km altitude from a BPL deployment, with 300 BPL devices visible to the receiver in a 314 km² area – 40 MHz

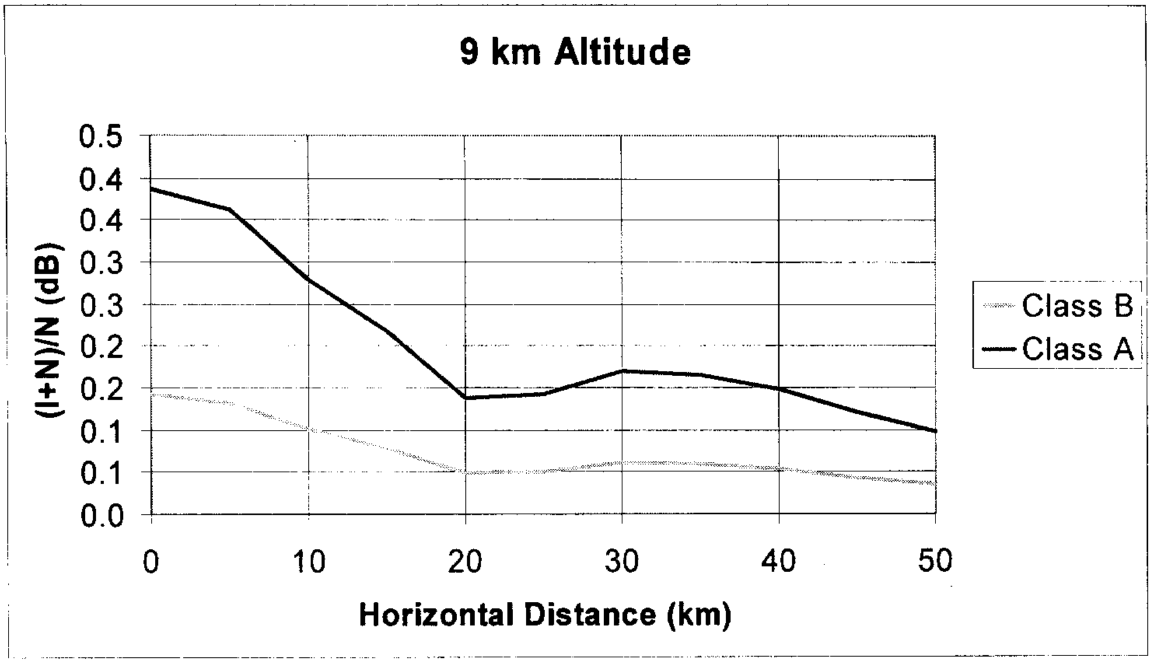

Figure 5-5: Calculated (I+N)/N level for an aeronautical receiver at the specified distance and 9 km altitude from a BPL deployment, with 300 BPL devices visible to the receiver in a 314 km^2 area – 40 MHz

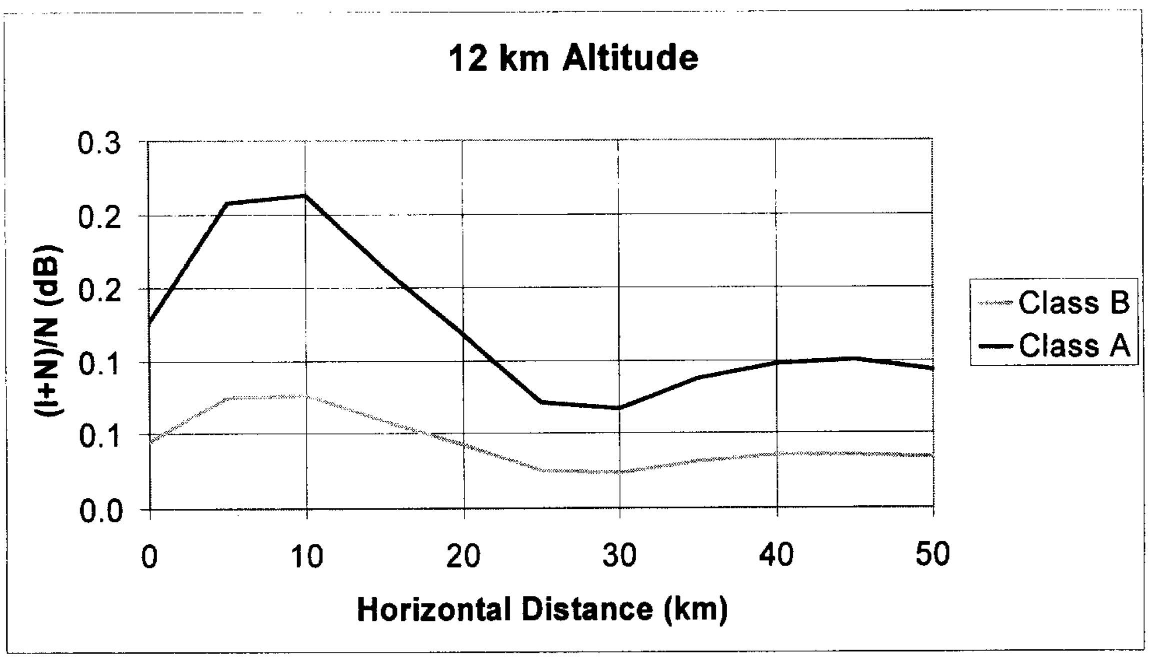

Figure 5-6: Calculated (I+N)/N level for an aeronautical receiver at the specified distance and 12 km altitude from a BPL deployment, with 300 BPL devices visible to the receiver in a 314 km^2 area – 40 MHz

5.3 ANTENNA HEIGHT CORRECTION FACTOR APPLIED TO THE LAND-MOBILE RECEIVER CASE

NTIA recommendations for enhancements to the Commission's Part 15 rules applicable to BPL systems are expected to yield significant reductions in the interference risks to federal radiocommunications. In its Phase 1 study, NTIA showed that there exists a substantial risk of interference to a land-mobile receiver due to a BPL transmitter operating at FCC Part 15 limits as measured using existing Part 15 measurement procedures.[13] For frequencies below 30 MHz, virtually all points close to an Access BPL power line would experience noise floor increases exceeding 10 dB. NTIA evaluated the probability that a land-mobile receiver would experience various levels of increased noise due to BPL interference, with the results shown in Table 5-1. Radiated power and noise are referenced to a 2.8 kHz bandwidth below 30 MHz and a 16 kHz bandwidth above 30 MHz. The table shows these probabilities with or without applying NTIA's recommended 5 dB measurement height correction factor. The results above 30 MHz in Table 5-1 are based on Access BPL operating at the Class B limit.

Table 5-1: Percentage of locations exceeding the specified interference level, by frequency, for a land-mobile receiver within 15 meters of an Access BPL power line.

With Height Adjustment								
Frequency	Radiated	Noise	(I+N)/N					
(MHz)	Power (dBW)	(dBW)	3 dB	10 dB	20 dB	30 dB	40 dB	50 dB
4	-74.79	-111.31	98.01%	81.54%	28.27%	0.00%	0.00%	0.00%
15	-72.32	-128.83	99.83%	98.85%	83.00%	34.97%	0.00%	0.00%
25	-69.88	-135.61	99.54%	97.52%	78.07%	39.32%	0.45%	0.00%
40*	-86.11	-134.27	66.05%	30.84%	0.00%	0.00%	0.00%	0.00%
Without Height Adjustment								
Frequency	Radiated	Noise	(I+N)/N					
(MHz)	Power (dBW)	(dBW)	3 dB	10 dB	20 dB	30 dB	40 dB	50 dB
4	-69.79	-111.31	99.33%	93.17%	54.69%	6.16%	0.00%	0.00%
15	-67.32	-128.83	99.85%	99.66%	95.69%	59.48%	4.28%	0.00%
25	-64.88	-135.61	99.78%	98.97%	92.11%	58.53%	18.52%	0.00%
40*	-81.11	-134.27	87.89%	49.15%	10.00%	0.00%	0.00%	0.00%

5.4 CONCLUSION

Figures 5-1 through 5-6 show that the operation of BPL devices at the Class A emissions limits, rather than Class B limits above 30 MHz, as determined using existing Part 15 measurement procedures, increases the distances at which a given percentage of locations experience a specified increase in receiver noise floor. Relative to operation under the Class B limit, the results for Class A show an increase of approximately 40 –

[13] *See* NTIA Phase 1 Study, at §6.6.1.

* Analyzed assuming BPL device operating at the Part 15 Class B limit.

50% in the distances at which receiver operation at a given percentage of locations would experience a given noise floor increase.[14]

NTIA evaluated the effectiveness of its recommendations for a measurement height correction factor and found that it only slightly reduces interference risks for nearby land-mobile receivers. After applying the height correction factor, most locations within 15 meters of an Access BPL power line will experience a noise floor increase of 10 dB or more at operating frequencies between 1.7 MHz and 30 MHz. To further protect land-mobile operations, other risk reduction techniques should be employed, such as power control and avoidance of use of mobile service frequencies in physically adjacent Access BPL network elements. Radio frequency noise on power lines can vary by upwards of 20 dB throughout a day; therefore, adjustment of BPL signal power to the minimum level needed for proper BPL device operation should result in an overall lowering of interference risks. Precluding reuse of mobile service frequencies in adjacent BPL devices lowers the probability that a land-mobile receiver will be operating co-frequency with BPL network elements within a large contiguous portion of the area served by Access BPL.

[14] *See* 47 C.F.R. 15.31(f)(1)

2.5 CONCLUSION

The figures in Section 2.3 show substantial variability of the height at which the peak field strength occurs. This variability can be seen over frequency and power line topology. In all cases where the operating frequency is above 6 MHz, the peak field strength occurred at heights greater than 1 meter. Below 6 MHz, the wavelengths are greater than four times the modeled power line height (12 meters) and under such conditions, it is expected that increased in-phase coupling between the power line and ground will lead to the highest values of electric field at or near ground level as explained below.

A long wire radiator is linearly polarized in the plane formed by the wire and the radial vector from the center of the wire to the observation point. Therefore, the direction of the linear polarization changes from point to point. Near ground, the polarization is almost vertical, especially when the height of the wire is small compared to wavelength. This is evident from graphical depiction of the vertical electric field in Figure 2-17 (p. 2-14) and comparison of this field with the two horizontal fields at 1 meter, as shown in Figures 2-15 and 2-16 (p. 2-12 and p. 2-13).

The figures illustrating the height for peak field strength, and the difference between the overall peak field strength and the peak at 1 meter show variability over the frequency range and also show variability from one power line structure to the next. One reason for this is that the ratio of the measurement height to wavelength changes and another reason is that all calculations are performed at a distance of 10 meters from the BPL energized power line. The figures in Section 2.4 show that the difference between peak field strength at any height and the peak field strength at 1 meter tends to range from about 4 to 6 dB.

Calculations for the real-world power line model (*see* Figure 2-2) produced results in substantial agreement with these findings. This model consists of a topology most closely resembling that of the "ver36n" model (over most of its extent, this model has a three-phase vertical with neutral configuration). The 80^{th}-percentile data for this model levels off at just above 4 dB at higher frequencies, as does the data for "ver36n."

In light of the variability of height where peak field strength occurs, NTIA recommends that measurements be performed at a height of 1 meter and use of a height correction factor of 5 dB. This will eliminate the need for an exhaustive search for the peak field in the height dimension, which could require considerable time and would not provide any statistical easement.